MYSORE GEOLOGICAL DEPARTMENT

Popular Studies No. 1.

AN INTRODUCTION

TO

THE GEOLOGY OF MYSORE

BY

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Director.

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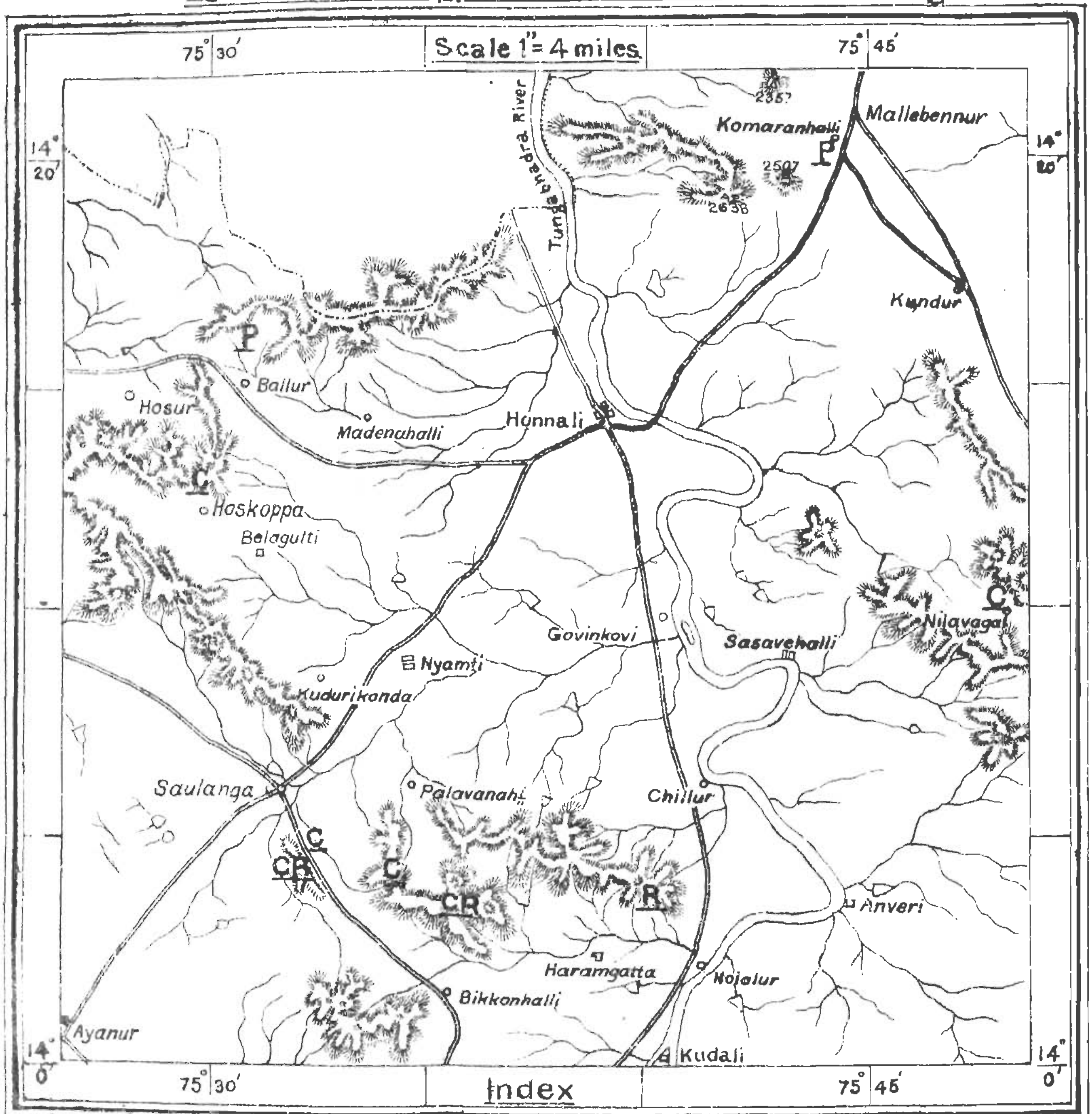
Localities of Ripple marks and Current bedding.



Rain prints = P. Current bedding = C. Ripple marks = R.

PREFACE.

The Mysore Geological Department was organised in 1895, to conduct a geological survey of the State and explore its mineral resources. Starting investigations soon after, it completed a preliminary survey of the State in the course of about 20 years. Within this period, a few selected areas were also re-examined, in detail, to verify the results of the preliminary work. This re-examination brought to light some new features which cast certain doubts on the results of the earlier work and indicated a need for its revision. Leaving, however, all doubtful questions to be solved by later detailed investigations and based on the results of the work done till then, a brief account of the geological formations of Mysore was published, in 1915, by Dr. W. F. Smeeth who was then the Head of the Department, and in that year a geological map of the State, compiled under his direction, was also issued. About the same time a 'Bulletin,' giving a comprehensive account of the State's mineral deposits was published.

In 1915, the Department was re-organised and there was a change in its general programme of work. As a result of this, a large share of attention of the Department was required for developing the State's mineral resources and consequently geological survey had to play, thereafter, a subordinate part. However, as time and opportunities permitted, small selected areas were taken up for revision and detailed investigation, and description on such areas were, as usual, duly given in the periodic publications of the Department. The main results of these later investigations have been

briefly dealt with in my presidential address to the Geology section of the 23rd session of the Indian Science Congress, and a detailed revised account of the Geology of Mysore will also be given shortly in one of the publications of the Department.

But all these, being technical papers, hardly reach the lay reader and interest him. Consequently, it should not be surprising if we find a large section of the public being unaware of the results of progress of the Geological investigations in Mysore and the present general scope of work of the Geological Department. To remedy this, to some extent at least, it is intended to issue hereafter a series of small books, as 'Popular Studies', which will give the main results of our investigations, without much of technical details, in a form suitable to the needs of the lay reader. This book forms the first in that series, and gives a brief, general account of the geology of Mysore as we interpret it now. It will be followed, in due course, by others, each one dealing in detail, with some special aspect relating to the geology of Mysore, or the mineral deposits of the State.

In a book dealing with scientific subjects it is impossible to avoid altogether technical expressions, and consequently a glossary of technical terms, and a brief description of the rock-forming and economic minerals of the State have been added at the end: and it is hoped the reader will find them useful.

The geological map of Southern India, illustrating this book has been slightly modified from the one which had been published, in 1915, by Dr. W. F. Smeeth, the modifications now effected being based mainly on the recent geological map of India, published by the Indian Geological Survey.

In writing this book for publication, I have derived very great help from my friends,—Mr. D. N. Wadia, Superintending Geologist,

(recently retired), Geological Survey of India; Mr. L. Rama Rao, Professor of Geology, Central College, Bangalore; and *Rajacharitavisarada* Rao Saheb Mr. C. Hayavadana Rao, Editor, Mysore Economic Journal. These gentlemen kindly went through the manuscript and offered valuable suggestions for its improvement, and to all of them I owe a deep debt of gratitude and can only express my heartfelt thanks. To Dr. M. H. Krishna, Director of Archæological Researches in Mysore, I am indebted for the loan of the half-tone block of Mallikarjuna temple at Basaral. To Mr. B. Viswanath, General Manager, Mysore Iron and Steel Works, I am indebted for the photograph of the iron ore dumps at Tanigebail; and to his Mining Assistant Mr. N. Panduranga Rao, for the photograph of the Bhadigund limestone. To Mr. Y. Nagappa of the Burmah Oil Company, I am indebted for the photograph of wind ripples at the Cape Comorin beach. All the other photographs for the half-tone blocks had been taken either by me or by other officers of the department during the course of survey work. The sketches for the line diagrams (a few adopted from well known text books on Geology), the sketch of the natural arch and the two maps have been prepared for me by Mr. K. Shankar Rao, Head Draftsman in the Department, to whom I am highly thankful. Finally, I have to thank Mr. B. Venkatasubba Rao, Superintendent, Government Press, and his assistants for their unvarying courtesy, promptness and neat execution of this work.

BANGALORE,
5th December 1938.

B. RAMA RAO.

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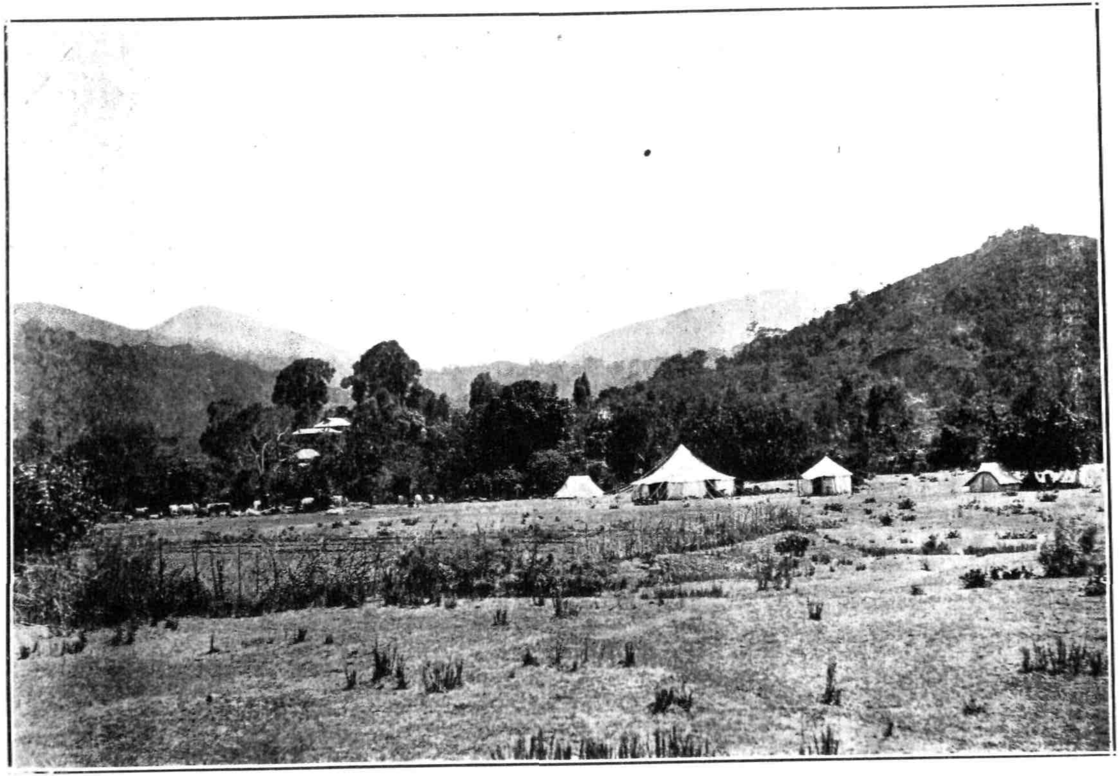

A Geologist's camp at Samse. In the distant background are the Kuduremukh hills, Western Ghats.

(Frontispiece.)

AN INTRODUCTION TO THE GEOLOGY OF MYSORE.

I. Geological Principles.

1. GENERAL GEOLOGY.

Geology deals generally with all the features of the surface of the earth; its origin, composition and structure; its history since the earliest beginning; and the evolution of life on our planet as recorded by the relics of animals and plants which inhabited it during past ages. Regional geology, such as is dealt with in this book, is necessarily limited in scope and gives only an account of the several rock formations of the region, the conditions under which they formed, the changes they have undergone, their distribution in space and the relation they bear towards one another and all other similar particulars ascertainable from a study of that region. To follow these specific accounts, without at least an elementary knowledge of geology, is not easy and therefore for the sake of those who might not be familiar with this science, a few of its salient aspects may be briefly outlined here.

Origin of the Earth.

Geology begins with the study of the origin of the earth. The precise way in which the earth has been formed is not really known. Several hypotheses have been put forward to explain its origin. Amongst those, two are outstanding—the nebular and the planetisimal—and they are directly opposed to each other in almost every point. The nebular hypothesis, the older of the two, suggests that the

earth was formed from the gradual cooling and contraction of a large, intensely hot, gaseous mass or nebula. The planetisimal hypothesis, led by Chamberlain and Moulton suggests, on the contrary, that the earth began as a small nucleus of solid meteoric matter and grew from the continued accretion of cold solid particles or *planetisimals.* According to the nebular hypothesis, the atmosphere and the earth's internal heat were there from the very beginning, but according to the planetisimal hypothesis they were formed during the later stage of growth of the planet. In either case, as seen now, the earth has formed into a body composed of a solid globe (lithosphere), cool on its surface but extremely hot in the interior, surrounded by two shells or envelopes,—an outer one of gas (atmosphere) completely encircling the planet, and an inner one of water (hydrosphere) covering about three-fourths of the globe.

Age of the Earth.

In whatever way the earth may have been formed, there is no doubt about its enormous antiquity. Throughout the Middle Ages, especially among the European nations, the earth was supposed to be 6,000 years old and it was not until the eighteenth century that a revolutionary suggestion was made that its age cannot be less than 80,000 years. This was before the Science of Geology had come into existence, and the development of that science quickly showed that the age of the earth must be reckoned in much greater numbers. Several lines of investigations during the nineteenth century led to the estimation of the earth's age from 50 to 400 million years. Of late, some methods have been devised which indicate with great precision the age of different rock formations. From one of these, which makes use of certain phenomena of radio-activity, it has been deduced that the earth must be more than 1,500 to 2,000 million years old.

Constitution of the Earth's crust.

A study of the accessible portions of the earth's crust shows that, beneath the mantle of loose surface soil, it consists everywhere of solid rocks which can be classified into two main groups;—the stratified or sedimentary, and the massive crystalline or igneous. A third group (metamorphic) also can be recognised, but this is made up of rocks formed from the alteration of the other two groups. The stratified rocks are estimated to cover about four-fifths of the land surface, but in point of abundance in the earth's crust they are, however, insignificant comprising only about five per cent. The remaining 95 per cent consists mainly of the massive igneous rocks mixed up with an indeterminable proportion of the metamorphic group.

Igneous rocks.

Igneous rocks are those which solidify by cooling from a molten state. They are termed igneous after the latin word '*Ignis*', meaning fire; but this is really a misnomer for, it is a very high temperature and not actually fire, which is involved in their formation. The igneous rocks form a large group and consist of many different types. Some are coarsely crystalline and others are almost structureless like glass. However, all of them are massive and not layered or stratified. It is probable that the original crust of the earth consisted of molten material and the first rocks to be formed were, therefore, igneous. But this does not mean that all igneous rocks are of a very ancient period. Igneous rocks have formed at different periods in the earth's history and in fact some of them are forming even at the present day.

Deep down in the interior of the earth are chambers or reservoirs of molten rock material. At different periods in the earth's history, from various causes, this molten material or *magma* forces itself through its overlying formations, to

the upper parts of the earth's crust. Sometimes, it reaches the surface and flows over it as liquid lava through fissures and volcanic vents. Often it may not reach the surface but congeal in the conduits, under shallow depths, either as a wall like mass of compact rock (dyke) or as a tabular sheet (sill); or it may consolidate, deeper down, under a cover of several thousand feet of strata as a large mass of coarsely crystalline rock, like granite. (Fig. 1.)

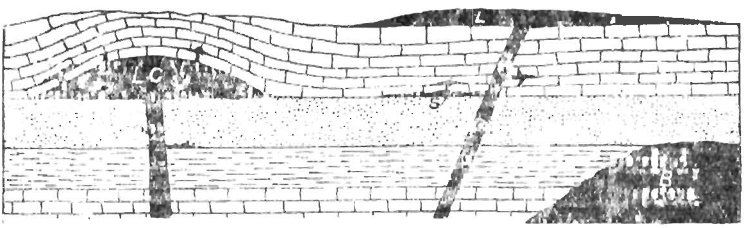

Fig. 1. Diagram showing depths of consolidation of igneous rocks in relation to surface.
L=Lava flow. S=Sill. D=Dyke. LC=Laccolith. B=Batholith.

Those that solidify after reaching the surface are termed volcanic or extrusive, and those which consolidate at profound depths, abyssal or plutonic. Between the two kinds, every transition may be found and the term hypabyssal is employed to masses cooled under shallow depths. Intrusive masses have been given different names like batholith, laccolith, etc., (for explanation of terms see glossary at the end of the book) according to the form or shape they have assumed after injection. Some of the plutonic rocks are now seen at the surface due to the removal of their overlying cover by denudation.

Sedimentary rocks.

Sediments are formed from settling or deposition of transported material derived from the breaking down and decay of pre-existing rock masses. When consolidated they form *sedimentary*, (stratified or

aqueous) *rocks*. They show a characteristic arrangement of their component materials in layers or beds.

The oldest or primitive sediments were evidently derived from the disintegration and decay of the earth's original crust which was primarily igneous. The later sediments, however, have got their material from the products of destruction of the land areas composed of all classes of rocks,—igneous, sedimentary or metamorphic. For the formation of sedimentary rocks two processes are necessary,—the destruction of pre-existing rock masses, and the transportation of their broken down products to some suitable place for deposition and final consolidation.

Denudation.

The processes of rock destruction and removal are grouped together under the general term *denudation*. Various destructive agencies, chemical and mechanical,—like temperature variations; wind and weather; rain and running water; snow and frost; ice and glacier, have all been ceaselessly operating from very remote times in wearing down the land areas. The result of this denudation is to reduce the higher regions of the earth to the level of the sea so as to bring about a uniformity of level in the earth's surface. If there were no contending forces this would have been accomplished long ago. But movements of the earth's crust, of various magnitudes, buckle up its surface producing new land areas, and may even rejuvenate the worn down and planed regions of the earth into fresh mountains thus exposing new rock formations for the denuding agencies to act upon.

The diurnal and seasonal variations in temperature aid to some extent in the splitting and disintegration of some kinds of rocks and in the arid regions specially, it is very effective. Sand

particles conveyed by gales of wind when hurled against rock masses cut and carve and wear them out. Very fantastic forms such as the well known Sphinx of Egypt have been carved out of rock masses from the effects of such wind blasts. The rain water chemically decomposes the rocks and converts them into soil. Part of the rain-fall, which flows over the surface as streams and rivers, wears out the land cutting and carving valleys; and the other part, which sinks underground and circulates through crevices and fissures, decomposes the rocks and removes the decomposed products in solution. The sea cuts its coast by the action of waves, and in a rocky beach, gullies and caves, grottoes and arches carved out of the solid rock, by the action of wind swept waves, are common. Snow and frost, congealing inside cracks and fissures of rocks, shatter them into fragments. The glaciers grind, polish and abrade their bed rocks and slowly wear out their surface.

Most of these agents are concerned not only in causing destruction of rock masses but also in removing and transporting the brokendown or *clastic* products from their place of origin; and in doing so, they lay bare fresh surfaces for further disintegration and decay. The process of denudation by these several agents gives rise to a large variety of land forms or topographic features.

Some of the denuding processes are so slow that they may take ages to produce any visible effects but others are so violent and rapid that we can easily notice their action. For instance, the lowering of the channel of a sluggish river, meandering in the plains, is hardly perceivable, but the effects of a mountain torrent rushing through a steep gradient, are easily seen. However, the annual waste of land from all these processes, at the present time, is estimated at about 26 thousand million cubic yards (4·8 cubic miles) and in the past ages, the volume of destruction of land surfaces

and the amount of material thus removed seem to have been much more.

Re-construction.

Let us now consider what happens to all the immense quantities of detrital or clastic material which, dislodged from its place of origin, is set on its downward journey towards the sea. It is estimated that one-half of it gets arrested in its course and forms inland deposits, and the other half completes that journey. The portion which eventually finds its way to the sea, or any other large body of water, after being roughly sorted and graded according to the size and weight of the component grains will settle down as sediments, the coarser particles like gravel being thrown down near the shore and the finer particles like sand and mud carried further away from land. (Fig 2). The

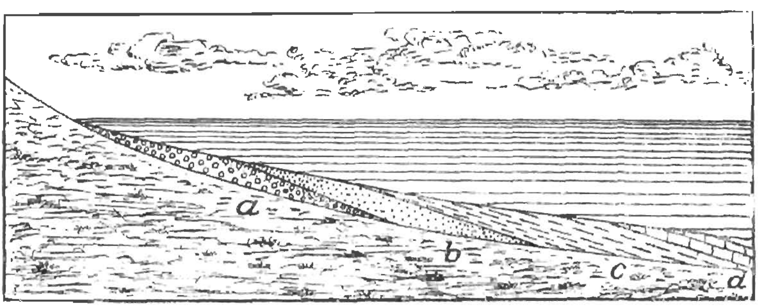

Fig. 2. Diagram showing order of deposition of sediments.
a=Coarse gravel. b=Finer sand. c=Silt and mud. d=Limestone.

material conveyed in solution like lime carbonate, iron carbonate and iron hydroxides, etc., will be precipitated, when conditions are suitable, by chemical re-actions or organic agencies. Far out in the sea, the deposits will consist only of very

fine muds, and minute particles of lime carbonates and silica forming the tests or skeletons of small marine organisms.

All these sediments are deposited layer after layer; the lower layer being the earlier in time of formation than the one above it. The thickness of such layers, (known also as beds or strata) may vary from a fraction of an inch to hundreds of feet, though generally it will be between 2 or 3 inches to 2 to 3 feet. A very thin layer is called a lamina.

From what has been stated above, it is seen that sedimentation may take place in any suitable body of water,—inland lakes, lagoons, shallow seas, and in deeper parts of the sea. The sedimentary deposits of each of these areas have their own characteristics, and those formed under shallow water can be easily distinguished from the deep sea deposits. For instance, apart from the coarseness of the grains, we often notice in shallow water deposits structures like current bedding (Fig. 3) and ripple marks produced by the action of

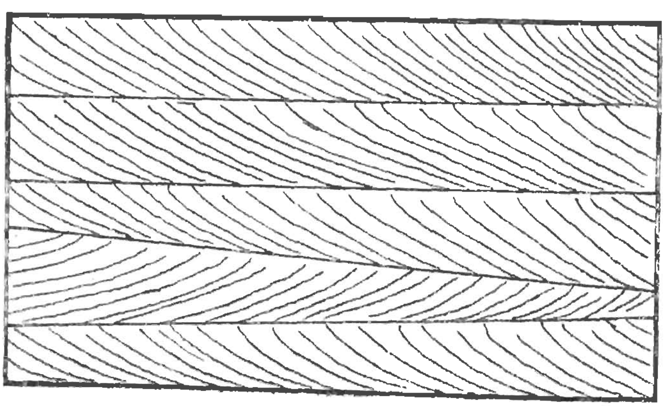

Fig. 3. Diagram showing current or cross bedding. Observe the finer laminations all being oblique to the main bedding planes.

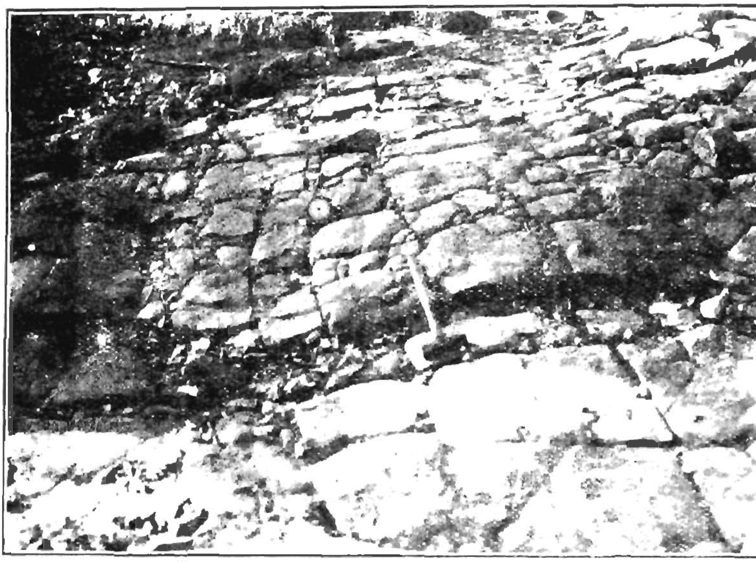

Fig. 5. Sun cracks preserved in ancient rocks

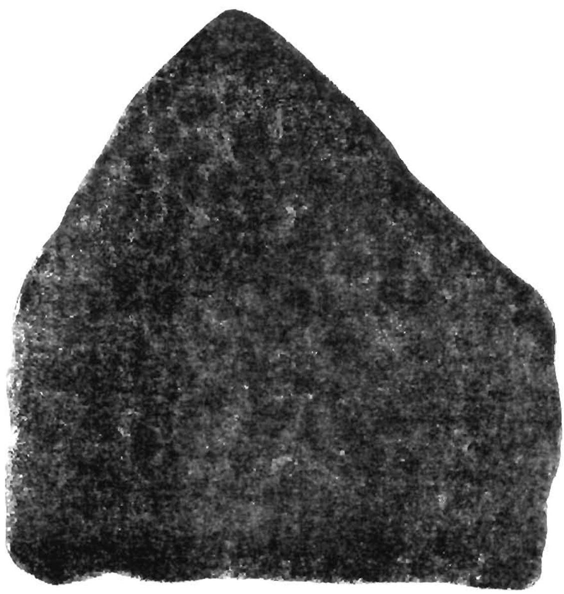

Fig 6. Rain prints in ancient silt-stone. Near Mallebennur, Chitaldrug District.

waves and currents ; sun cracks, (Figs. 4, 5.) pro-

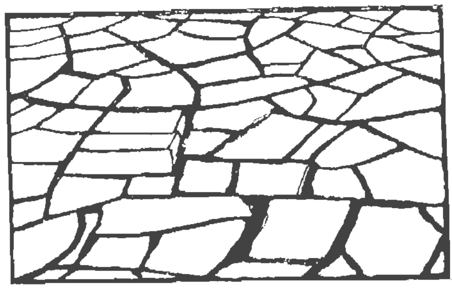

Fig. 4. Diagram showing sun cracks.
(Commonly seen in dried up tank beds).

duced in muds due to their shrinkage in volume while quickly drying ; rain prints (Fig. 6), foot prints of animals ; trails and burrows of worms, etc., which are not found in the deep sea deposits.

The layers of sediments as deposited are usually horizontal or very slightly inclined if deposited in a sloping shelf. (Fig. 7). By subsequent earth

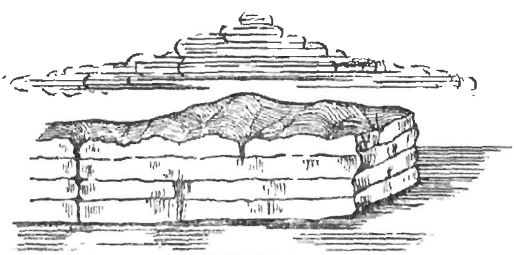

Fig. 7. Sketch showing horizontal bedding.

movements they may get tilted, and incline at an angle to the horizontal plane. (Figs. 8 & 9). In extreme cases, the beds may stand vertical, or even get overturned.

Several factors, such as the weight of overlying beds, pressure, compression, heating, cementation,

etc., bring about the consolidation of the loose and incoherent masses of sediments. On such consolidation, coarse gravel will form a conglomerate; sand, a coarse grit or fine sandstone; mud and silt, a mudstone or shale; lime carbonates, limestones; and so on, and these will constitute a bedded series of sedimentary or stratified rocks.

Metamorphic Rocks.

From various causes, both igneous and sedimentary rocks may be highly altered from their original conditions. Induced pressure may produce fracture, planes of cleavage, foliation and other structures in rock masses. The compression and heating of rocks when subjected to earth movements may lead to their re-construction with the development of new structures and minerals. In a similar way, intrusions of igneous rocks may produce profound alterations in the older rocks with which they come in contact. From one or another of these several causes, a sandstone may be converted into quartzite; a mudstone or shale, into slate or schist; a limestone, into marble; a granite may get crushed into a foliated gneiss; and a compact basalt, into a greenstone schist. Such altered rocks are classed as *Metamorphic* rocks. The alterations produced in different rock formations may vary in degree and kind. Extreme alterations may destroy all the original characters of rocks and in such instances, it is difficult to ascertain if the altered rocks were originally igneous or sedimentary. This difficulty is very commonly experienced in ancient rock formations, such as those found in Mysore,

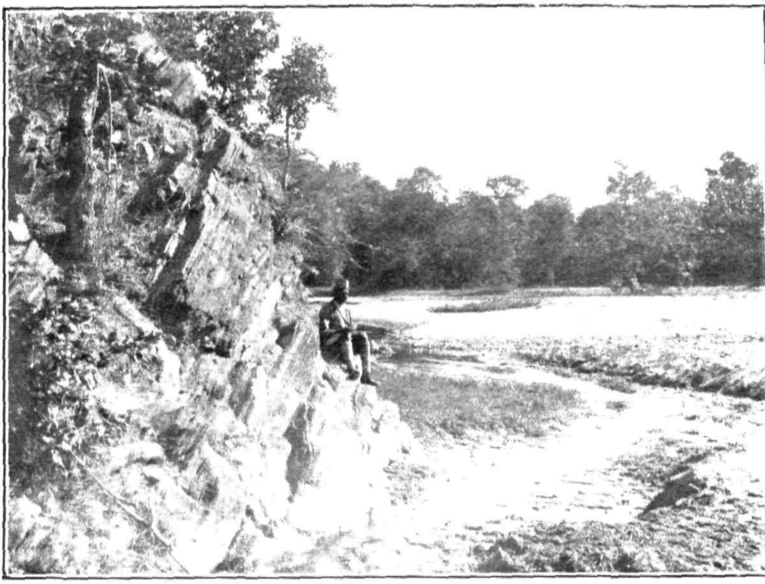

Fig. 8. Inclined Strata. The beds dip at about 45° to the left.

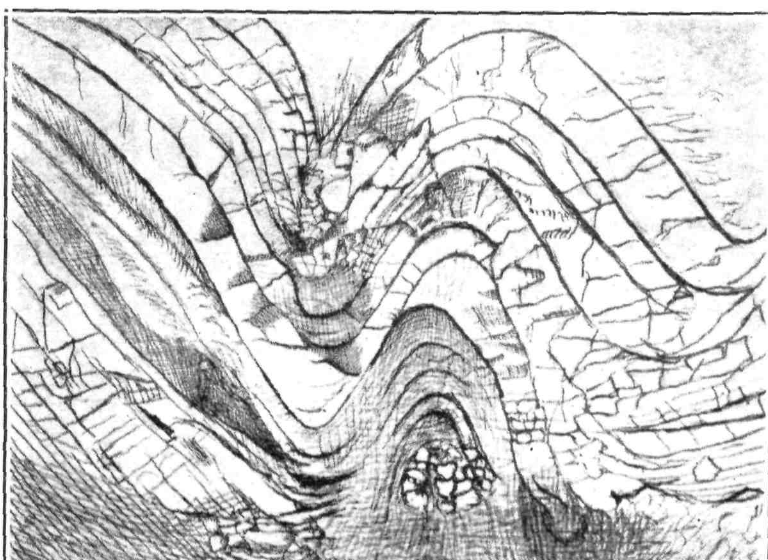

Fig. 9. Contorted Strata. Observe the folding of beds into a narrow trough (syncline) and an arch or saddle (Anticline). Byadarhalli, near French-Rocks.

2. HISTORICAL GEOLOGY.

Oscillations of sea level.

From the foregoing account we see that the destruction of land areas, composed of different classes of rocks, will ultimately lead to the formation of sediments. This, however, is only a part of the story. The earth has not been a finished product and its history does not end with this single chapter. Various causes bring about constant changes in the relative levels of land and sea. Portions of land get submerged beneath the sea, and the sea floor gets squeezed up high and dry to form most intricately corrugated or folded mountain chains. When the sea floor is raised to form a solid land mass, there is not only a stoppage of further sedimentation in the area, but the newly constituted land mass will itself be worn down in time, from the process of destruction by several of the denuding agencies already considered, and furnish material for a fresh series of sediments elsewhere. When this planed down land mass gets submerged again beneath the sea, it will form the base for the deposition of a subsequent series of sediments. Therefore, these alternate elevation of sea floor and submergence of land areas beneath the sea give rise in time to the formation of a pile of sedimentary beds of different periods or ages.

Fossils.

For a very long time after the formation of the earth—extending perhaps over many millions of years—its condition remained unsuited for the support of life. Gradual cooling, and improvement in other physical conditions, paved the way for the first appearance of the most primitive forms of life on this planet and since then progressive evolution has led to the appearance of several types of organisms at different periods. Many of these groups of animals and plants, after playing their part for several generations, disappeared in their turn from the stage of

the earth's history. Fortunately, for us, those ancient denizens of the earth have left their relics in the rocky strata. Harder parts of these organisms are found scattered about in various states of preservation in several rock formations of different regions. These relics are known as *fossils*. In one place, there may be the skeletons or bones of some large land animal scattered through a superficial gravelly deposit; at another, minute shells or skeletons of some sea organisms embedded in mud stones. Limestones crowded with remains of corals; coal beds with relics of leaves and stems of ferns and club mosses (lycopods); clay stones with trails of worms or marks of foot prints of birds and land animals, and similar other innumerable pieces of evidences enable the geologist to visualise, in some measure, what the fauna and flora of successive periods have been and the physical conditions under which they flourished. By a comparative study of these organic remains, the geologists have found that there is a definite order in the appearance of the several types of animals and plants which have yielded these fossil remains, that each group of rocks is marked by its own special type of fossil life, that these types can be recognised and classified, and that the rock groups of different regions in which similar types of fossils are found can be correlated as of the same period of formation, even though they may be far distant from one another. A careful study of this fossil record, though often incomplete and effaced, still affords an important clue to the stratigrapher (geologist engaged in the study of different strata) to re-construct the earth's history during the several stages of its progress to its present condition.

Classification of Strata.

From a comparative study of the arrangement of strata over wide areas, and on the recognition of major breaks, in the deposition in the column of strata and in

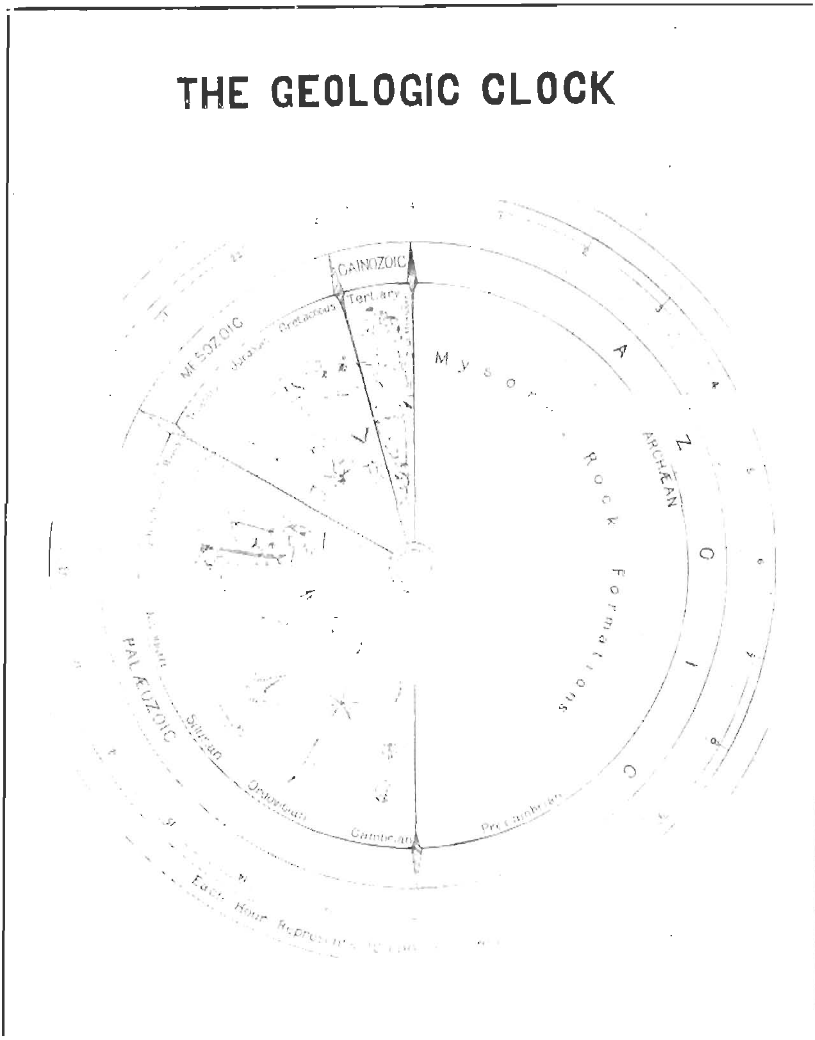
THE GEOLOGIC CLOCK
CAINOZOIC
Tertiary
Cretaceous
Jurassic
MESOZOIC
Mysore Rock Formations
ARCHÆAN
AZOIC
PALÆOZOIC
Silurian
Ordovician
Cambrian
Pre-Cambrian

Fig. 10.

the stages of organic evolution, the geologists have classified, for purposes of description, the entire strata of the earth into five major eras based on the stages of evolution of life, as noted below :—

Cenozoic	... ...	Meaning the period of Recent life.
Mesozoic	... ...	,, Middle life.
Palæozoic	... ...	,, Old life.
Proterozoic	... ...	,, Earlier life.
Archæozoic	... ...	,, Ancient life.

The Archæozoic and Proterozoic have also been grouped together, by some geologists, into an Azoic or period of no life. The major eras have been sub-divided into a number of periods ; and each of such period has been further sub-divided into epochs. Corresponding to the time scale, the rock formations have been divided into major groups, the groups into systems, the systems into series, the series into stages, and the stages into sub-stages and zones.

Geological Clock.

To get a relative idea of the duration of each of these successive eras in the earth's history, let us conceive of the time elapsed from the formation of the earth to the present day, as a day of 24 hours. On this scale, the geological history relating to the Archæozoic and Proterozoic eras is believed to have extended a little over 12 hours of our conjectural clock ; that of the Palæozoic era, about 8 hours ; of the Mesozoic era, about 3 hours ; and of the Cenozoic, about an hour. (Fig. 10). In the Cenozoic, the Quaternary period,—the latest division constituting the period since the advent of man, forms only the last 10 to 15 minutes of the hour. We see now how very late in the evolutionary scale the advent of man on this planet has been.

Classification of Indian Rock Formations.

The rock formations in India have been classified by Sir Thomas Holland * into the following four major groups :—

(i) The Aryan group.
(ii) The Dravidian group.
(iii) The Purana group.
(iv) The Archæan group.

The sub-divisions of these four major groups are correlated, as far as practicable, with the several chronological systems of rock formations of the standard scale of Europe as set forth in the accompanying table.

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*Sir Thomas Holland was formerly the Director of the Geological Survey of India. He has given a succinct account of Indian Geology in the Imperial Gazetteer of India, Volume 1, 1907.

A very much recent and more detailed account is furnished by Mr. D. N. Wadia, in his excellent book, on "The Geology of India," which forms at present a standard text book on the subject.

TABLE OF GEOLOGICAL FORMATIONS.

Eras	Periods, or Systems of Strata		Equivalent Formations in Peninsular India		Typical Life
Cenozoic	Pleistocene and Recent	Quaternary	Aryan	Recent alluvia, sand dunes, etc. Kurnul cave deposits—Older alluvium.	Man and Modern Mammals.
	Pliocene	Tertiary		Laterite	......
	Miocene.			Cuddalore sandstones	Ancestors of Modern Horses, Elephants and Rhinoceros, etc.
	Oligocene.				
	Eocene.			Deccan Trap ...	Primitive mammals.
Mesozoic	Cretaceous.			Marine cretaceous of Trichinopoly. Bagh beds of Central India.	Culmination of Reptiles. Appearance of flowering plants.
	Jurassic.			Upper Gondwanas, Marine beds of East Coast.	Gigantic reptiles. First appearance of birds.
	Triassic				Primitive reptiles.
Palæozoic	Permian.		Dravidian	Lower Goudwanas. (The Coal measures of India).	Primitive amphibians.
	Carboniferous.				Enormous development of flowerless land plants.
	Devonian.				Abundance of fishes.
	Silurian.			Absent ...	Primitive fishes.
	Ordovician.				Graptolites.
	Cambrian.				Trilobites—Marine invertibrates.
Archæozoic	Algonkian.		Purana	Vindhyan-Kurnul Formations.	Organic remains very doubtful.
				Cuddapahs, Bijawars, etc.	......
	Archæan.		Archæan	Dharwars and Intrusive Granites.	......
				(Mysore rock formations entirely confined to this period).	......

NOTE.—The wavy lines in the above table indicate breaks in deposition in the column of strata.

II. Geological Record of Peninsular India.

Geologically speaking, Mysore forms part of what is called Peninsular India and therefore before we proceed to a detailed study of its geological history let us see what the geological record has been in Peninsular India as a whole.

Archæan Period.

In the Peninsular India to the south of latitude 22°, a large part, including Mysore, is comprised mainly of the oldest rock formations of the earth's crust. The geological record of this ancient period is very difficult to decipher, and this is true not only in India but also in other parts of the world. These ancient rock groups, forming the Archæan system, constitute a complex of highly crumpled crystalline schists and gneisses massed into a confused jumble, and consequently the task of separating them into recognisable sequence of stratigraphic units has proved well nigh impossible. The available evidences indicate, however, that the period opened with tremendous igneous activity which continued for a very long time when lava flows, of different types, were poured out over the surface of the earth; their products of decay giving rise to local sedimentation. Similar sequence of events evidently occurred in this portion of the world, which we now call Peninsular India. This complex series of lavas and their associated sediments, forming the present day Dharwar Schists, were crumpled and puckered into corrugated mountain ranges by the propulsive force of several subsequent granitic masses. The granites, coming up from below, have pierced, disrupted, and disfigured the base of Dharwar Schists, so much, that it is practically impossible now to recognise the original foundation on which the lavas had flowed.

Cuddapah Period. At the close of the Archæan period, Peninsular India formed an extensive land area composed of this complex formation of highly folded schists and granitic rocks. An extremely long period of denudation extending, perhaps, to a thousand million years, followed, during which the rocks forming the highlands were slowly worn down to the level of the sea. The upper covering of the Dharwar Schists was completely removed in some places, exposing the underlying granitic rocks. A sea encroached over a part of this worn down land area, and allowed the accumulation of a great series of sediments which was subsequently raised to form a new land mass. The remains of these sediments cover an area of about 14,000 sq. miles in the Cuddapah district and are known as the Cuddapah System.

Vindhyan—Kurnul Period. The Cuddapah sea, retreating from its basin, exposed the series of rock formations to atmospheric denudation for a fairly long time, after which a part of the denuded land again got submerged to receive another series of sediments, remnants of which are preserved in the Vindhyan range of mountains in Central India and other parts, and in the Kurnul district, in Southern India. During this period there were some minor oscillations of sea level and consequently breaks in the deposition of sediments. The Vindhyan System is notable for its diamond bearing rocks found near Banganpalli, in the south; and Panna and Sambalpur, in Central India. The Kohinoor and other well known Indian diamonds came from these areas.

After the formation of the Vindhyan System, there is an enormous blank in the geological history of Peninsular India, extending over many millions of years during which time the palæozoic sediments, from the Cambrian to the Carboniferous, (see Table

1, p. 15) were being accumulated in the north of the Peninsula. Of those great formations, in which the earlier records of the evolution of life forms are preserved, there is no trace in Southern India which has remained all through as a solid block or buttress of land unsubmerged beneath the sea through all these geological ages, unlike some other portions of the earth's crust which were alternately depressed below the sea and raised again into dry land many times during that period.

Towards the close of the Carboniferous period, Peninsular India formed part of a great continental area extending through Madagascar and South Africa to South America on the one side and through Malay Archipelago to Australia on the other. This old continent, called Gondwanaland by Geologists, formed a land barrier between a Southern Ocean and the great Eurasian Sea in the North (the Tethys) which extended from Central Asia over northern India, where the Himalayas now stand, into Europe, and of which the present Mediterranean sea forms a shrunken relic.

Gondwana Period.

By about the end of the Carboniferous period, the geological record is again taken up in Peninsular India, by the commencement of a long period of inland sedimentation in lakes and river basins. The ancient land mass consisting of the Archæan and pre-Cambrian rocks was being slowly worn down during the whole of the Palæozoic era and the larger rivers had reached their base level of erosion with the result that their sluggish movements had been developing swamps and marshes. At the close of the Carboniferous period, there were some large scale earth movements and, as a release of tension of these movements, a series of parallel fissures or rifts were formed in various parts of the Peninsula. The ground gradually sank along these lines of weakness giving rise to a number of depressions in the older gneissic land. The debris of land

decay including the remains of abundant vegetation transported by the large rivers were discharged into these basins or depressions. The process of accumulation of such fresh water sediments continued for a very long time, possibly for some 150 million years, from Permo-Carboniferous to the end of Jurassic or even to the beginning of the Cretaceous period and resulted in the formation of a considerable thickness of beds, classified by Indian Geologists as the Gondwana System. This system contains, nearly, all the workable coal seams of India. During the later part of this period, forming the upper Gondwana epoch, the Southern sea encroached slightly on the Coromandel coast and received the detritus of the adjacent land area.

Cretaceous Period.

During the next period, the Cretaceous, (the period of chalk formations of Europe) the physical conditions in India were very diversified. In Peninsular India, the sea transgressed again over parts of the Coromandel coast, and this gave rise to the most interesting patches of sediments in parts of the Trichinopoly district. An arm of the northern sea also seems to have transgressed along the present Narbada valley giving rise to what are known as the Bagh beds.

Tertiary Period.

With the end of the Cretaceous period, the Mesozoic Era is closed, and we enter into the next Era, the Cenozoic, which includes the two large periods,—the Tertiary and the Quaternary. The two terms, Tertiary and Quaternary, have been somewhat loosely used by some, as Eras; and by others, as Periods. In accordance with the American usage, we may consider them, as 'Periods' and their sub-divisions, 'Epochs.'

From the closing time of the Cretaceous period to the early part of the Tertiary, the region of northern India was thrown into successive convulsions. These powerful earth movements started to

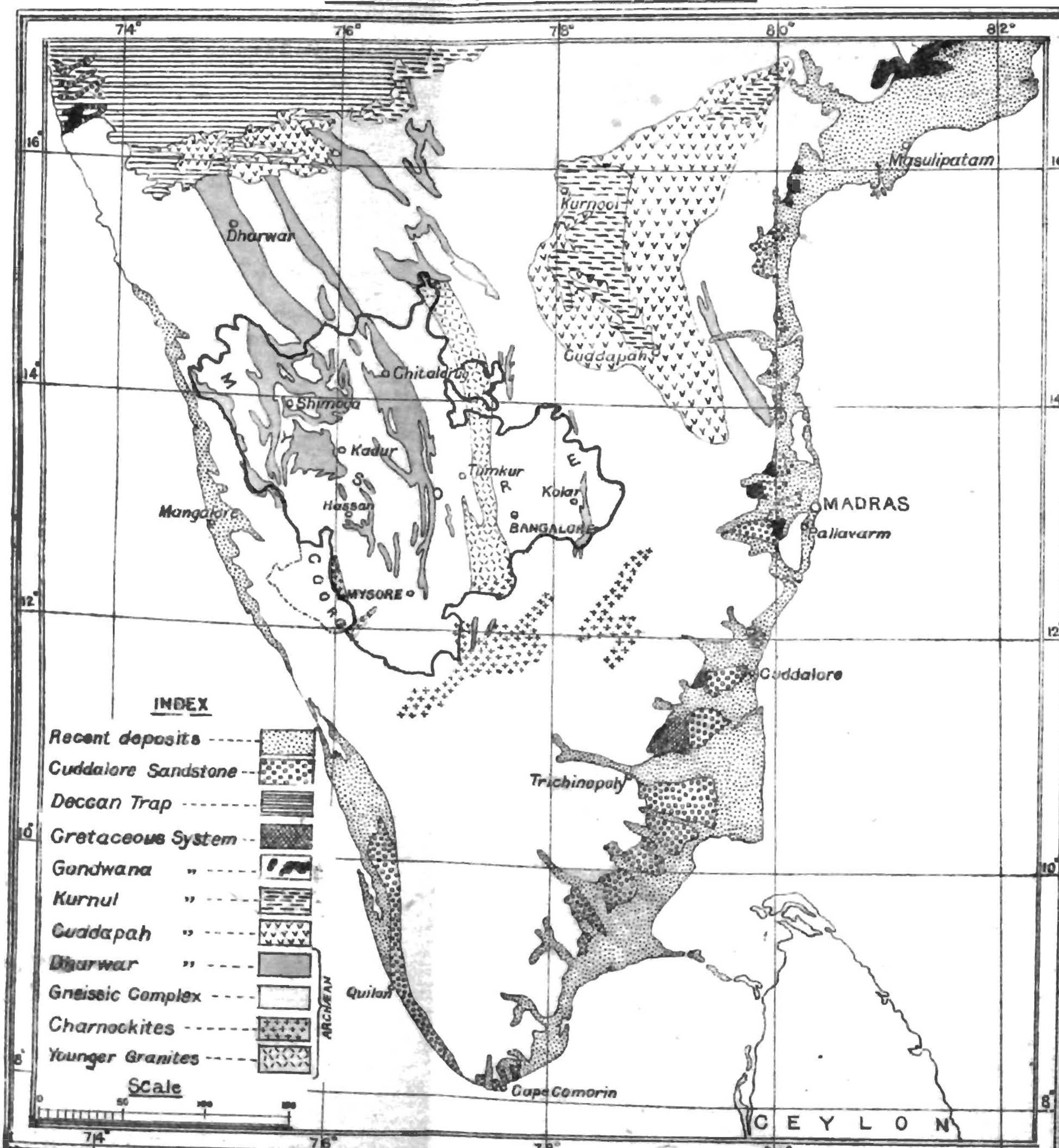
crumple and lift up the enormous accumulations of sediments formed in the Tethys, to give rise ultimately to the mountain chains which constitute the present Himalayas. Successive uplifts in later epochs raised the Himalayan range to stupendous heights, and drove back the Tethys to the present confines of the Mediterranean Sea. Thus, what was once a sea bottom is now represented by one of the youngest and the highest among the mountain ranges of the world. Towards the dawn of the Tertiary period, the Gondwanaland began to break up and the land connection between Peninsular India and South Africa disappeared beneath the present Arabian Sea.

Deccan Trap.

In Peninsular India these earth movements, at the dawn of the Tertiary period, were accompanied by igneous action on a gigantic scale. As a result of such movements numerous fissures and cracks were formed in the north-western part of the Peninsula, through which welled out, intermittently, enormous quantities of liquid lava accumulating to some thousands of feet in thickness. The relics of this stupendous volcanic formation, now covering an area of some 200,000 sq. miles in Bombay, Central India and Hyderabad, are known as the Deccan Trap.

The southern part of the Peninsula, however, was left unruffled by these movements. The Tertiary period in Southern India has not produced any striking events. There have only been some minor accumulations of marine sediments along the coast, such as the Quilon limestones in Travancore, the Ratnagiri rocks of the Malabar coast, and the Cuddalore sandstones which extend along the east coast from Vizagapatam to Tinnevelly, comprising mainly of some loose textured sandstone. The formation of *laterite* which is found in many parts of South India, especially, all along the west coast, is usually ascribed to this period.

GEOLOGICAL MAP
OF
SOUTHERN INDIA.



LITHO GOVT PRESS BANGALORE.

Quaternary period.

Fewer still are the changes which are noticeable in Southern India during the post Tertiary or the Quaternary period. During recent times the sea has encroached at certain places as at San Thome near Madras, and has receded at certain other places as at Karkoi on the Tinnevelley coast. A few catastrophic earthquakes have produced some minor changes in the topography of the regions where they occurred in Northern India, but have not affected in any way Southern India which continues to stand as a stable land mass.

In Southern India, or the part of the Peninsular India south of latitude 16° (*vide* Map), therefore, if we exclude the coastal strips, we have an area formed almost entirely of the most ancient series of rocks, uncovered by any later formations comparable to the fossiliferous formations of the other parts of the world.

III. The Mysore Archæan Complex.

With this brief glance at the geological record of Peninsular India, we will now turn back and consider in some detail the nature of the rock formations of the immensely old Archæan period to which the geology of Mysore is almost entirely confined.

The Mysore plateau consists of about 29,000 sq. miles of which a sixth of the area is comprised of crystalline schists, and the rest, of a heterogeneous mass of granites and granitic gneisses. The schists occupy fairly wide areas in the northern parts of Mysore and are continuous with those exposed in the neighbouring districts of Dharwar, in the Bombay Presidency. They were first recognised as different in age to their associated granitic gneisses and were constituted into a separate formation in that neighbourhood. In accordance with the common procedure in naming local rock

formations, they are called rocks of the Dharwar System or shortly, Dharwar Schists. At first, the Dharwar Schists were believed to have been laid down on the eroded. uneven surface of their underlying granitic gneisses but detailed investigations, in Mysore, have clearly proved that all the granitic rocks came into their position very long after the Dharwar schists had been formed and, as such, none of them could have formed the base on which the schists were laid down. Therefore, so far as we can see, the Dharwar System appears to be the oldest among the rock formations of Mysore and we will consider them first.

I. DHARWAR SYSTEM.—(General Characters).

The Dharwar System is composed mainly of a complex series of crystalline schists, igneous rocks and their altered forms, and some presumable sedimentary rocks like quartzites, conglomerates, limestones, etc.

Schists.

The Schists are composed of several varieties like hornblende schist, chlorite schist, talc-chlorite schist, tremolite-actinolite schist, mica schist, kyanite sillimanite schist, graphitic schist and many other types. They are highly crystalline and are altered very much from what they were when they were first formed. It is now difficult to ascertain whether they are all igneous or sedimentary in origin or which amongst them are actually igneous and which sedimentary. In the case of some, like the dark hornblende schists, we find traces of original igneous structures and can safely presume that they are the altered forms of basic volcanic rocks, but in the case of others there are no reliable clues and, therefore, we cannot be certain as to how they were actually formed.

Igneous Rocks.

The igneous rocks also are composed of several types. They are mainly volcanic and consist mostly of lava flows, intrusive sheets and sills of variable character and composition. The basic rocks form basalt, dolerite, epidiorite and other altered types which may be commonly described as greenstones. The acidic types are composed of rhyolite, felsite, quartz porphyry, granite porphyry, etc., and their altered forms. In some parts we also find remnants of what might have been ashes, tuffs and other comminuted products of volcanic ejections, and agglomerates.

Sediments.

The sedimentary group consists of types like quartzite, conglomerate, argillite and phyllite, limestone, and ferruginous quartzite or banded iron stone. Rock types like these are usually sedimentary in origin, but in very ancient geological formations very similar types are also known to have been produced from alterations of igneous rocks. Therefore when dealing with very old formations, like those of the Mysore Archæan Complex, reliable proofs would be needed to decide the sedimentary or igneous origin of such rocks. For a long time we had found no such proofs and consequently doubted very much if these rocks were really sedimentary. However, of late, *structural* evidences have been discovered, in some parts of Mysore, which conclusively prove the sedimentary origin of some of them.

A general study of the Dharwar System, as found in Mysore, will show that it is not so intensely altered in the northern parts of the State as it is in the south. Consequently to understand the true nature of the rock formations of this System we should begin our studies in the northern areas. As seen there, the main characters of the prominent types of the sedimentary group may now be considered.

Quartzites.—True quartzites are formed from the crystallisation of sandstones, but acid igneous rocks like felsite, quartz porphyry, fine grained granites and also veins of quartz when crushed and deformed will often give rise to quartz schists which would be almost indistinguishable from them in appearance. For a long time, it was considered that all the quartzites in the Dharwar system were of igneous origin. But recent investigations have brought to light well preserved relics of current bedding (Figs. 11 and 12) and ripple marks (Figs. 14 and 15) in the quartzites exposed in the northern regions and consequently, now, there need be no doubt whatever about their sedimentary and shallow water origin.

Conglomerates.—A true conglomerate indicates its shallow water origin. But in very ancient rock formations like the Archæans, a false conglomeratic structure containing apparent pebbles and matrix, develops from various causes (Figs. 18 and 19). For instance, in complex igneous rocks subjected to severe crushing, the harder parts stand out like pebbles while the softer portions yield and flow round to form the *role* of matrix. While some of the conglomeratic rocks in Mysore are of this type, there are others which seem to be truly sedimentary in origin, (Figs. 16 and 17) and of these, we can recognise two groups which seem to have formed at different periods.

Argillites, Phyllites, Mica Schists, etc.—These rocks are usually formed from different degrees of alteration of sedimentary clays, muds and silts. Compact basic volcanic rocks when deformed and decomposed may also give rise to rocks which may resemble phyllites and mica schists.

In the northern parts, thin bands of foliated argillites, phyllites and micaceous schists are found at some places, interleaved with quartzites and conglomerates, and at others, they are of larger extent and contain only thin bands of quartzite.

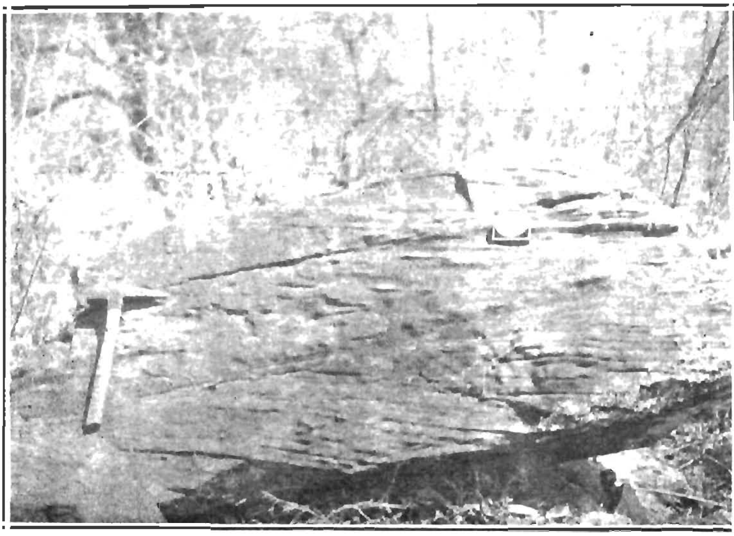


Fig. 11. Current bedding in the Dharwar quartzites. Note—the hammer rests between two bedding planes; and the edge of the compass, parallel to oblique laminations. Near Saulanga, Shimoga District.

Fig. 12. Current bedding in quartzites. Near Saulanga, from another spot.

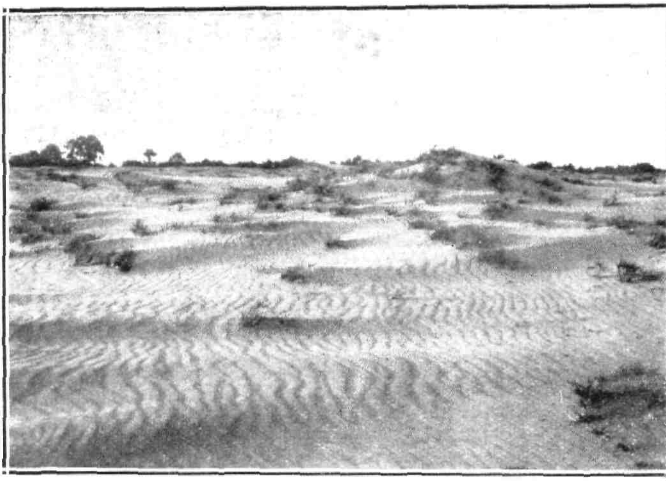


Fig. 13. Wind ripples in sands. Cape Comorin.

Fig. 14. Ripple marks in the Dharwar quartzites. Near Saulanga.

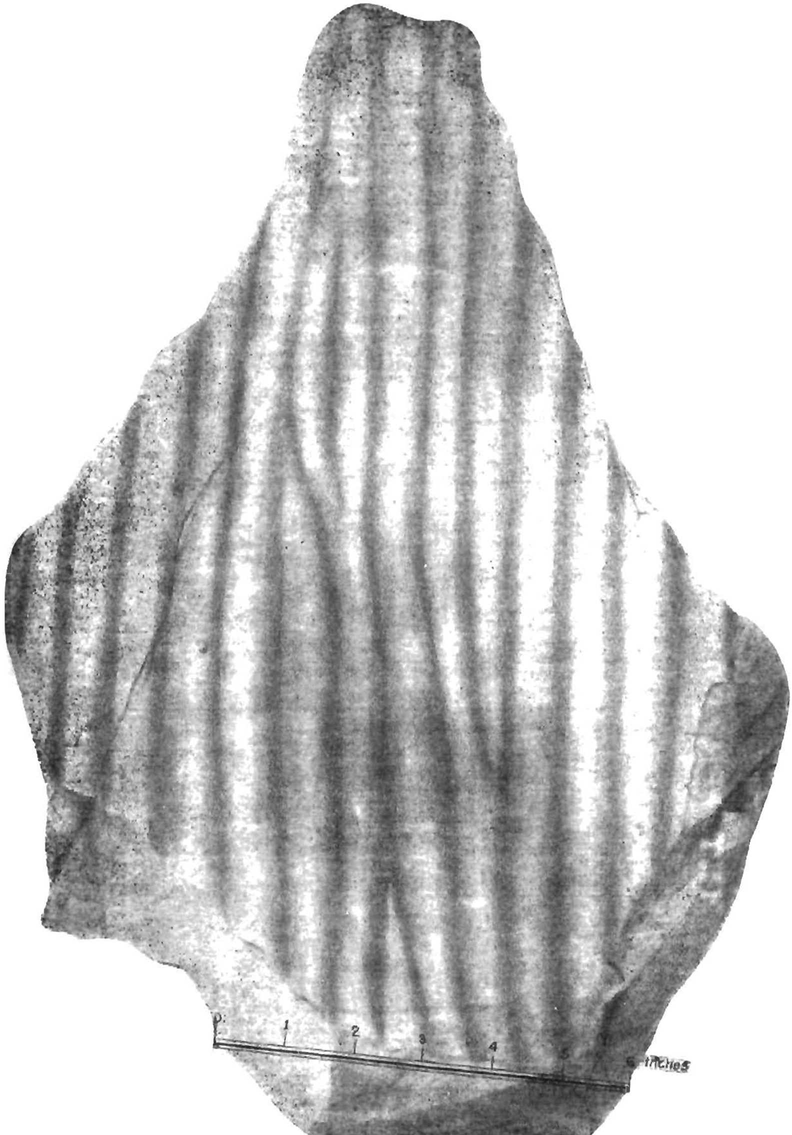


Fig. 15. Sketch showing a near view of the ripple marks in Fig. 14.

Fig. 16. A typical conglomerate. Observe, the pebbles are perfectly smooth and rounded.

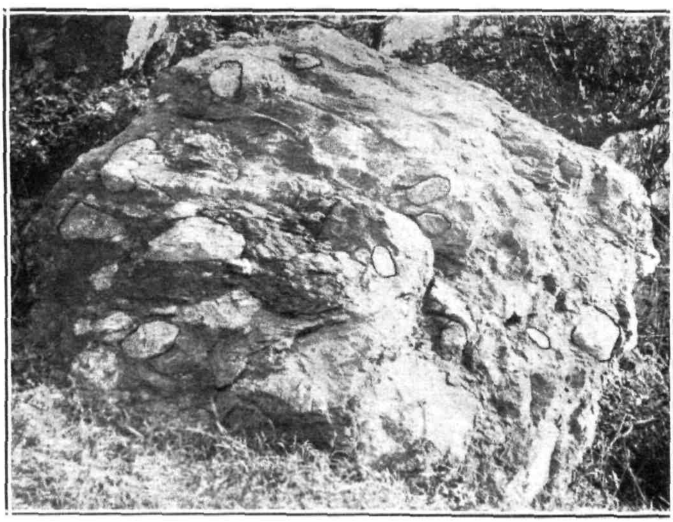


Fig. 17. A conglomerate in the Dharwar system. Observe, the pebbles are sheared and their rounded outlines cannot be easily made out. Kaldurga, Kadur District.

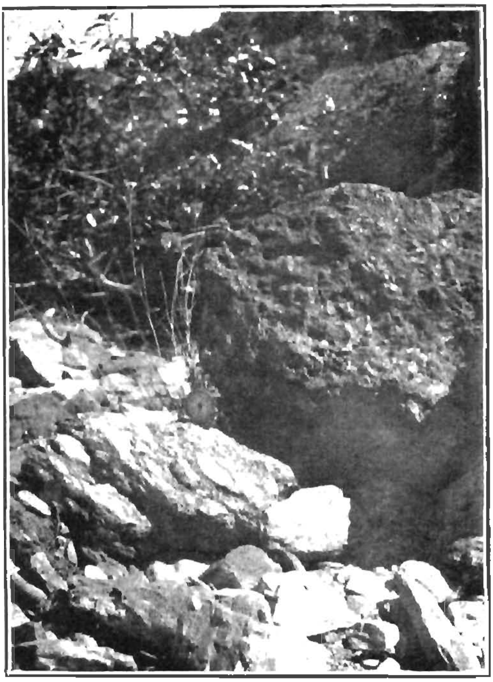


Fig. 18. Pseudo-Conglomerate formed from the crushing of an igneous rock and its inclusions; near Chitaldrug.

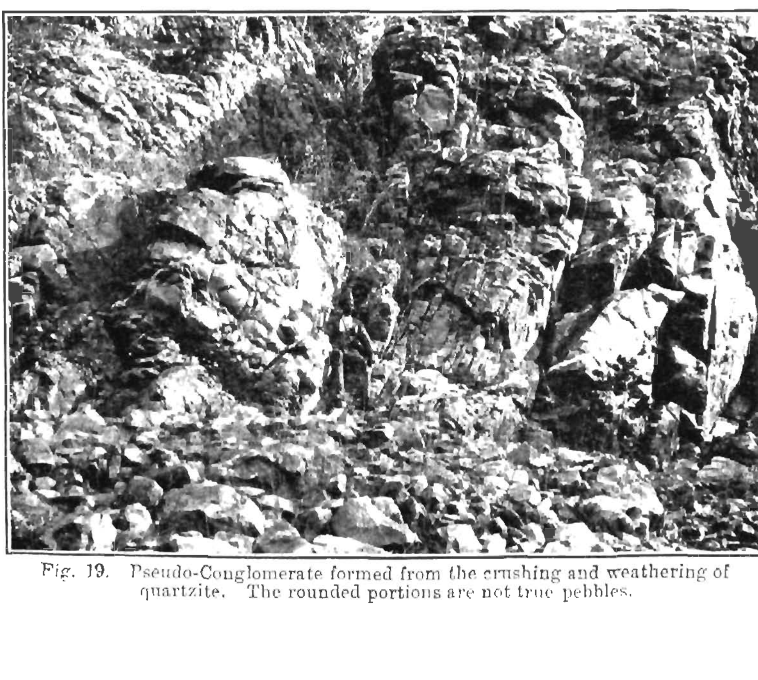


Fig. 19. Pseudo-Conglomerate formed from the crushing and weathering of quartzite. The rounded portions are not true pebbles.

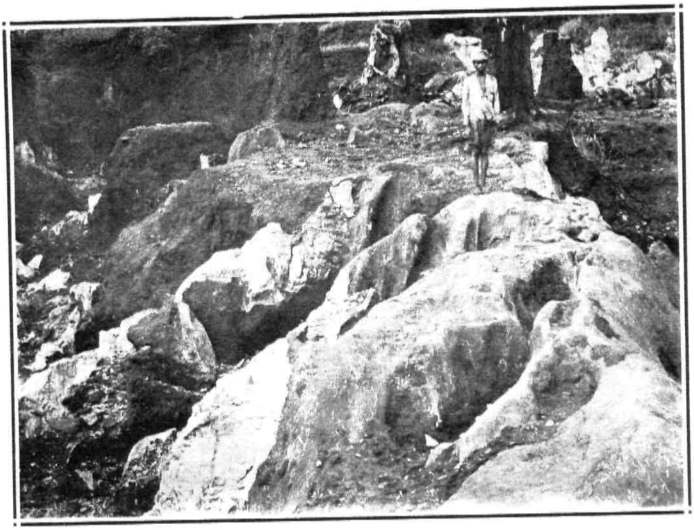


Fig. 20. A Dharwar limestone. Note its massive character and canoe-shaped weathering. Bhadigund, near Bhadravati.

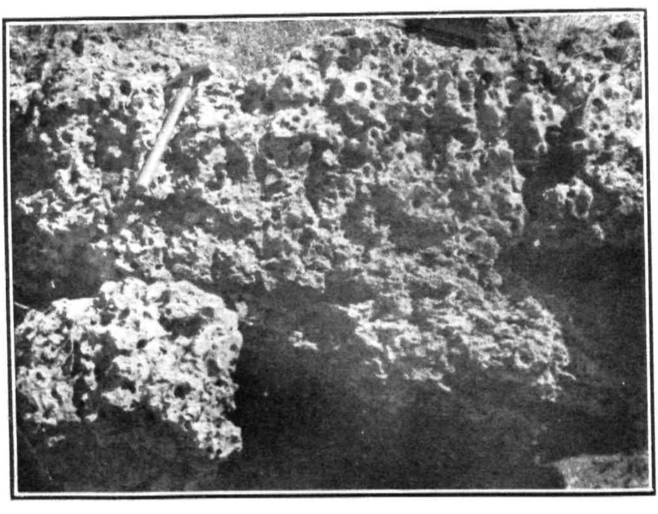


Fig 21. Concretionary limestone. Note its tubular, lateritic weathering, Near Chitaldrug.

They are highly crumpled and have so completely lost their original characters that, by their present appearance, it is impossible to say anything definite about their origin. However, since they are found interbedded with quartzites, of definite sedimentary origin, and since in their chemical composition they resemble very much the altered clays, we may regard them as highly altered sediments like clays, muds and silts. In the southern districts, they have become very highly crystalline and have developed many new or secondary minerals.

Limestones.—The exposures of limestones found in Mysore are all coarsely crystalline. They vary in colour from dark to light grey, and in composition, from highly calciferous types to dolomitic or magnesian varieties (Figs. 20 and 21). In some of their exposures there are also a few thin patches of pure white limestone composed almost entirely of coarse calcite crystals. The highly calciferous limestones show, here and there, badly preserved signs of stratification, but the magnesian types are generally massive. The larger bodies of limestone are interbedded with the quartzites and argillites which, as we know, are sedimentary and therefore we may regard the limestones also to have had a similar origin.

Banded Iron Stones.—These are heavy, dark brown rocks which are composed mainly of grains of iron ores, and quartz. In Mysore, there are many varieties of iron stones which have formed under different conditions. We will consider here, only the most commonly occurring type in the Dharwar system,—and this is, the banded iron stone. This rock consists of minute dark layers or bands of iron ores, alternating with lighter ones, composed mainly of grains of quartz. The bands

are often folded in highly complicated patterns. (Fig. 22)

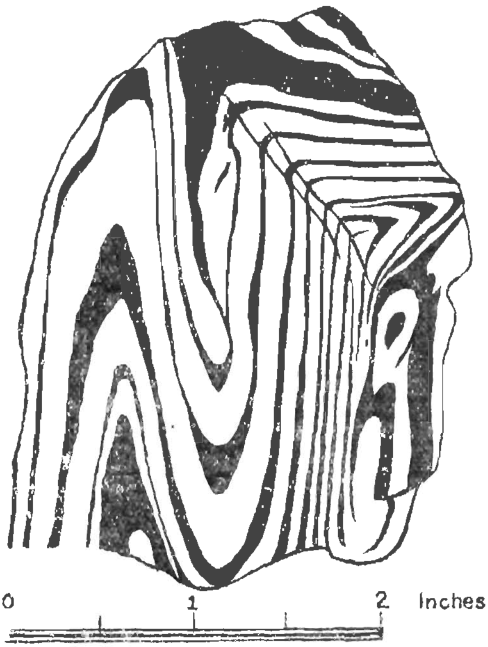


Fig. 22. Diagram showing the complicated folding in the banded iron stones.

At some places, the banded iron stone is found interbedded with limestones, argillites and chloritic schists, and at others, it rests directly on decomposed basic volcanic rocks or greenstones. The mode of origin of this rock and the precise way in which its banded structure has been produced are not yet quite clear. From some of the evidences recently obtained we may reasonably assume that the banded iron stone also, has been formed under water. In the northern area of the State, in parts of the Shimoga and Chitaldrug Districts, the rock consists mostly of grains of hæmatite and quartz. But in the south, due to subsequent alterations, it has developed some other

minerals, the most interesting being a new variety of amphibole, Bababudanite—so called from its discovery, some 30 years ago, in some of the iron stones of the Bababudan hills.

Granulites.

In the south western part of Mysore and also, as isolated stringers, in some other areas of the State, are a series of granulitic crystalline rocks which contain a distinctive set of minerals like kyanite, staurolite, sillimanite, graphite, cordierite, corundum, garnet, etc. All these minerals are not found together in the same rock but some two or three of them may be found in association in any one type. These rocks have not been closely studied, but it is inferred that they are also sedimentary in origin and have assumed their present forms due to the repeated alterations from the effects of igneous intrusions of different periods.

Glancing back for a moment we see now that among the rocks of the Dharwar System, there are some which are undoubtedly igneous; others, certainly sedimentary; and a good many, formed presumably from the alterations of the one or the other. There are also some types which belong to neither of these three categories. They form a class by themselves and have originated from the intermingling, in different proportions, of both igneous and sedimentary material.

Ultrabasic Rocks.

Passing now from these components of the Dharwar System, we come next to a series of rocks such as those from which we get the potstones, soapstones, serpentine and magnesite. These rocks are all highly magnesian and are classed with the ultrabasic group among igneous rocks. They are found as irregular sheets amidst the Dharwar schists in the Hole-Narsipur and Krishnarajpet areas, and as long narrow lenses amidst the complex granulitic rocks in the south western part of the Mysore District. Since they are cut out by

the granites along with the Dharwar schists, they have been included in the Dharwar System.

Basic intrusives. Finally there are some large masses of basic igneous rocks, diabasic or dioritic in composition, such as those found in the neighbourhood of Bellara, Santaveri, and Jogimardi and other places near Chitaldrug, which have intruded into the Dharwar schists, but have been themselves cut out along with the latter, by the granites and consequently form part of the Dharwar System.

2. DHARWAR SYSTEM—(Classification, Distribution and Mineral Wealth).

CLASSIFICATION.

Unsatisfactory data. All the several rock groups of the Dharwar System have, evidently, not been formed at the same time, but they have been so confusingly jumbled up that it is almost impossible to unravel their structure from this tangled skein and arrange the rock groups in their proper order of formation. Moreover, the fact that the rock types have altered considerably from their original condition and not always in the same way either in the different areas, and the fact that those formed in different periods under different conditions have, more often than not, become almost alike in appearance by their subsequent alterations, adds in no small measure, to our dilemma. Therefore a reliable classification of this puzzling complex into groups of any definite order of formation is beset with considerable trouble.

Earlier Classification. Based on lithological grounds, that is to say, on the general character of rock types, the Dharwar System was divided in 1916, by Dr. Smeeth, into two

separate divisions. In the lower one were placed the dark hornblende schists, epidiorites, and some thin bands of limestones and banded iron stones: and in the upper, chlorite schists and greenstones; micaceous schists, conglomerates, quartzites, limestones, and banded iron stones; and schistose felsites, quartz porphyries and other types of acidic volcanic rocks, together with a highly crushed micaceous granitic gneiss.

Proposed Classification.

Dr. Smeeth's classification, though convenient for purposes of preliminary survey and mapping, does not indicate the true order of formation of the several series of rocks in the System. A more satisfactory method to classify the Dharwar System into separate divisions would be, one based on stratigraphic breaks as shown by the disposition of true basal conglomerates.

As stated before on page 25, we can recognise in Mysore two groups of conglomerates, formed at different periods. The older of these consists, almost entirely, of pebbles of quartzites; and in the younger, we have pebbles not only of quartzites but also of granites, banded iron stones, greenstones, and some other types. Based on the occurrence of these two classes of conglomerates, we may divide the Dharwar System, into three divisions, as follows:—

Upper Division.—Thin series composed of the younger conglomerates, friable quartzites, ferruginous silts and mud stones, and thin bands of limestones, admixed with volcanic material.

Middle Division.—Largely sedimentary consisting of older conglomerates, quartzites, clay schists, chloritic and micaceous schists, limestones and banded iron stones admixed with volcanic material. There are also some basic and acid intrusive igneous rocks in the series.

Lower Division.—Mainly igneous consisting of basic and acid lava flows, and intrusive dykes

and sills. There are no clearly recognisable sedimentary rocks in this series.

DISTRIBUTION.

It has already been suggested that, at the close of the Archæan period, the Dharwar System probably covered the whole of Southern India as a very thick corrugated mantle concealing beneath it the complex of granitic rocks, which had intruded at different periods into the base of the System. Much of the original cover has been worn away since then and only the deeper portions of that corrugated mantle, saved from further destruction by denuding agencies, are preserved still, here and there, as isolated bands or patches of varying dimensions. These, we generally call Schist Belts and they form, in the aggregate, about 5,000 sq. miles in Mysore. For purposes of description, they may be grouped into three main bands—the western, the central and the eastern.

The Western Band.—The western band is by far the largest of the three and forms an important section of the Dharwar System; but it is broken up into a number of large irregular patches, separated by granites and gneisses. It covers in Mysore, altogether, an area of a little more than 3,000 sq. miles. Comprising of a large part of the eastern half of the Shimoga District, the band continues in a south-east direction forming the Bababudan belt in the Kadur District, the Hole-Narsipur belt in the Hassan District and finally, the Krishnarajpet belt in the Mysore District.

Shimoga belt.

The *Shimoga belt*, which forms the largest patch in the western band, covers an area of about 2,500 sq. miles and forms the continuation of the belt of schists of the adjoining Dharwar District,—the type area for the Dharwar System. In this belt, all the prominent types of rocks, of which the

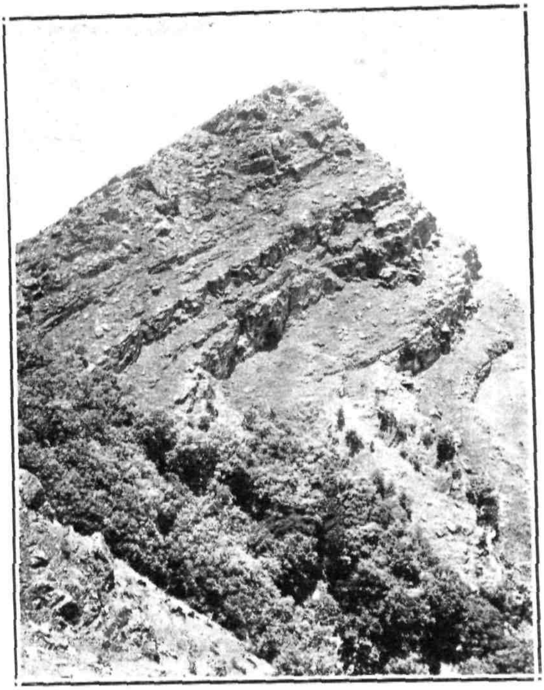


Fig. 23. Scarps formed of ferruginous quartzite (Banded iron-stone). The beds dip at a low angle to the left. Bababudan hills.

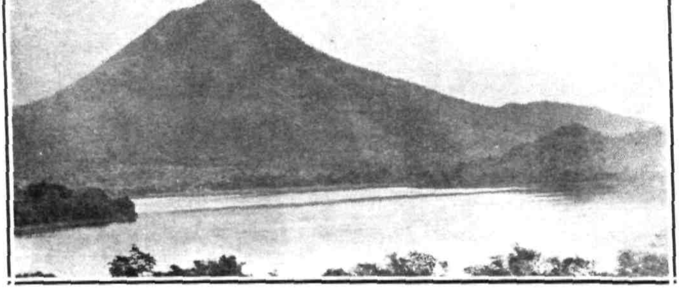


Fig. 24. Configuration of hill formed of vertical beds of ferruginous quartzite flanked by softer schists. Sakunagiri hill, near Birur, Kadur District.

Dharwar System is composed, are found fairly well preserved. Structural evidences indicating the sedimentary origin of the quartzites and conglomerates are found as relics near Saulanga, Hosur and other places (see map opposite). It is from a careful investigation of the different parts of this schist belt that the above classification of the Dharwar System into the three series or divisions has been suggested.

The lowest division, as we have seen, is made up almost entirely of acid and basic volcanic rocks of several types. The products of their disintegration and decomposition formed the source for the oldest recognisable sedimentary rocks in the region which, together with some igneous rocks, constitute the middle division. In some parts of this schist belt, this division is overlain by another thin series of sediments which commences with a layer of the younger conglomerates. This, we may consider as a third series, forming the upper division of the Dharwar System.

From complex folding and from several other causes all these series of rocks have been so disturbed and altered that it is not always possible to recognise their proper sequence of formation in every place. Therefore, we will only mention the main series of rocks found in the other parts of this band, without giving a detailed classification in each case.

Bababudan belt.

Bababudan Belt.—Immediately to the south of the Shimoga belt lies the Bababudan belt, but cut out from it by the granitic rocks of the Shimoga and Tarikere regions. It consists of about 500 square miles and is composed mainly of iron ores and banded iron stones which form the crest and summits of the Bababudan range of hills (Figs. 23 and 24), while the hornblendic rocks and greenstones are exposed on their lower flanks and further down in the valley. To the north-east and

east of the Bababudan range are exposed a series of rocks made up largely of chloritic schists, conglomerate, quartzite, thin bands of limestone, and some ultrabasic igneous rocks and their alteration products: and these are all similar to the rocks of of the middle division in the Shimoga belt.

Hole-Narsipur belt.

Hole-Narsipur Belt.—Some distance to the S. E. of the Bababudan belt is the small but extremely interesting belt of schists, near Hole-Narsipur, which covers only about 100 sq. miles. It forms, more or less, a connecting link between the less altered schists of the northern areas and the more highly altered strips and stringers of schists exposed further south in the Mysore District. The belt is comprised of numerous interesting rock types containing highly altered igneous and sedimentary formations and other rock types formed from several complex processes.

Krishnarajpet belt.

Krishnarajpet Belt.—To the south east of Hole-Narsipur belt are two other isolated patches of schists which form the *Krishnarajpet* (also known as Attikuppa) and the *Hadnur belts.* They consist mainly of some hornblendic and serpentine rocks, and there are no reliable indications of the presence of sedimentary rocks in the region.

The Central Band.—The central band of the Dharwar schists forms a continuous belt and runs through the middle of the State with a N. N. W. trend in the Chitaldrug District, where it attains a maximum width of 25 miles. Passing southwards through the Tumkur and Mysore Districts, the belt splits up into narrow branches and finally disappears a few miles to the south of Seringapatam. It has a total length of about 170 miles in the State and covers an area of about 2,000 square miles.

Fig. 25. Current bedded quartzite pebble, found in a conglomerate bed, indicating the sedimentary origin of the conglomerate containing it. Near Holalur, Shimoga District.

Chitaldrug Belt.—The main rock types of the Chitaldrug belt are, more or less, similar in appearance to those which we noticed in the Shimoga

hitaldrug belt.

t. In the Chitaldrug belt also, current bedding l ripple marks are preserved in the quartzites ır Talya, Madadkere and near Chikkonnanhalli. the conglomerates near Talya, here and there, ɔbles of current bedded quartzites have been ınd, just as in the conglomerates of the Shimoga t (Fig. 25).

Though the geological structure of the Chitalıg belt is more complicated due to the larger num· of intrusions of basic igneous rocks, yet we find a ıeral parallelism in the order of succession of the limentary formations of this belt with those of ; Shimoga belt. In the central part of the italdrug belt, where the basic igneous rocks are gely exposed, the sedimentary rocks are very ignificant (Fig. 27); but on the eastern and stern sides they are quite prominent and resemble character the sedimentary rock formations of ; Shimoga belt. In this belt, there are numerous posures of dark hornblendic rocks which are not ıspicuous in the Shimoga belt. Among the limentary formations of the Chitaldrug belt also, o separate sets of conglomerates, like those of ; Shimoga belt, can be recognised. Based on ;ir distribution, the Chitaldrug belt can, similarly, classified into three separate divisions which rrespond in a general way, to the three divisions the Shimoga belt.

Proceeding southwards the belt gets narrower d to the S. E. of Chicknayakanhalli hornblendic ;ks are found in larger proportions. The rocks ; all more altered than in the Chitaldrug area d conglomerates are rare. As we trace these ;ks further and further southwards we find them ɔre and more altered and consequently it becomes ry difficult to recognise and separate the

remnants of true sedimentary rocks from the igneous ones.

The Eastern Band.—The only conspicuous band in this region is the well-known Kolar Schist Belt. Situated near the eastern end of the State, in the Kolar District, this belt of schists extends north and south for a distance of 40 miles with a maximum width of 4 miles covering in all an area of about 100 square miles. Owing to its importance as the centre of the gold mining industry in the State, in fact in all India, the geology of this schist belt has received considerable attention from the officers of the State Geological Department, from the geologists attached to the gold mining companies, and also from other expert geologists who have occasionally visited the area for various special studies.

Kolar belt.

The Kolar schist belt is composed mainly of dark hornblende schists which vary from fine to coarse in texture. They are considered to have been originally formed as a series of basic lavas. Along with them, there are some thin bands of rocks which contain tremolite and actinolite. They are classed separately and termed amphibolites. Close to the eastern and western edges of the belt, there are some "conglomeratic rocks" and siliceous schists, which are considered to be igneous in origin.

Scattered in the gneissic area to the west of this belt of schists are some isolated stringers of rocks which contain cordierite, sillimanite, corundum and other minerals. These may, perhaps, represent the altered remnants of the sedimentary rocks comparable to those of the middle division of the Dharwar System in the Shimoga belt.

Besides these three main bands, there are a few other stringers of the Dharwar schists scattered about in several parts of the State.

Sargur Granulites.—Apart from these several belts and patches of distinctly recognisable Dharwar

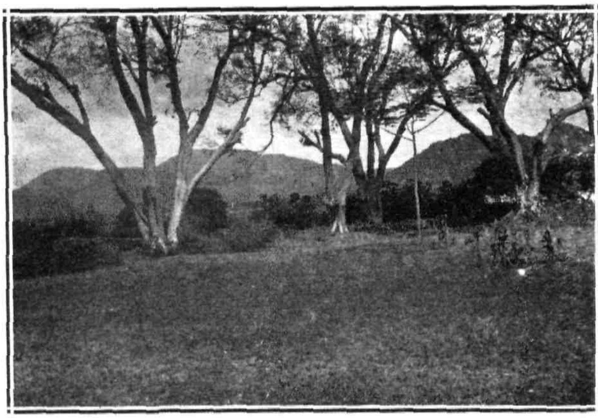


Fig. 26. Topography of hills formed of "Sargur granulites"; north of Sargur. Mysore District.

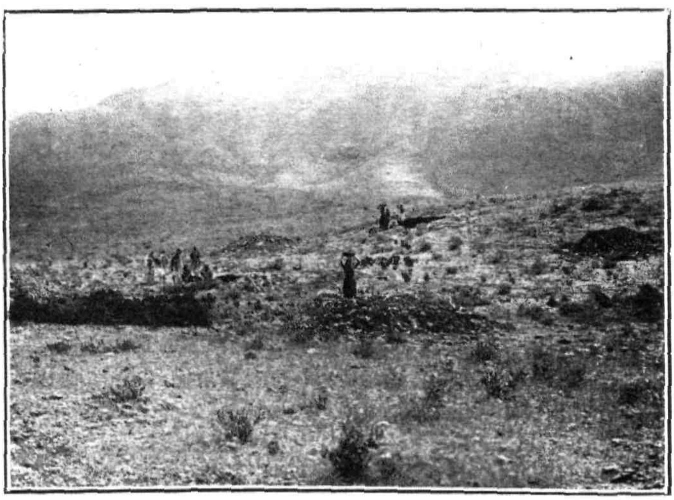


Fig. 27. Topography of hills formed of clay schists,' the clay hills are in the distant background and the foreground is a complex of chloritic schists and trap, containing veins of lead-antimony ores, on which are some prospecting shafts. Near Chitaldrug.

ts, there are some bands of metamorphic rocks h contain varying proportions of sillimanite, ite, staurolite, graphite, corundum, garnet, and other minerals, associated with granulitic ous rocks covering a fairly wide area in the n western part of the Mysore District. They typically seen near Sargur (Fig. 26). With schists are found, at certain places, a few bands of crystalline limestone, and some led iron stones containing magnetite, diopside, rsthene, garnet and quartz. There are also ral types of ultrabasic igneous rocks which at in places intrude the schists;—and some of n, to the east of this complex zone, contain able deposits of magnesite and chromite. ng to the isolated nature of these highly talline rocks, we have not been able to ascer-, as yet, whether they form part of the Dharwar em and if so, to which of its particular sions.

Progressive Alterations.

Summarising this necessarily brief account of Dharwar System we see that several varieties rocks, formed under diverse conditions, are prised in it. In the northern parts of the te, where the rocks are least altered, better served, and exposed over wide areas, it is possible us to recognise, to some extent, their original racters and to classify them into three separate tigraphic divisions. As we proceed southwards, topmost members disappear having been oved by denudation, and those of the lower tions get gradually split up and torn apart from another by the granitic rocks which have aded them. Consequently the severed members, h their varying degrees of alteration, being jointed and scattered in the gneissic complex, not be arranged, in these areas, in any clearly

recognisable order of succession. The banded iron stones, which have escaped, to a considerable extent, denudation on account of their weather resisting qualities, have developed new minerals; the clay schists have become thoroughly crystalline and altered almost beyond recognition; the lime-stones and quartzites, become less conspicuous in the central parts of the State and where they do occur, they are so highly altered that their sedimentary origin is a matter of doubt, and further south they are still less conspicuous or have almost entirely disappeared. The conglomerates also, are less conspicuous in the central parts where they are considerably sheared, and since some other rocks assume in this area, a false conglomeratic aspect due to several obvious causes, it is not always easy to separate the true conglomerates from their false proto-types. They disappear altogether further south. Among the several types of volcanic rocks, which form such conspicuous members of the lower division of the Dharwar schists, in the northern parts, only some hornblende schists and foliated greenstones are noticeable, and the acidic rocks are not seen. Probably they are incorporated as unrecognisable remnants, in the later granitic rocks and form an integral part of the gneissic complex.

Mineral Wealth.

The Dharwar System in Mysore, has been found to be the storehouse of many of the State's economic minerals.

Gold.—The quartz reefs, encased in the dark hornblende schists of the Kolar Gold Field, have already produced, during the last sixty years, gold, to the extent of 18 million ounces, worth more than a hundred crores of rupees. Quartz veins, which intersect the chloritic schists of the Shimoga, Chitaldrug and other parts of Mysore, have also

28. Alluvial washing for gold in the bed of the Tungabhadra river. Near Holalur, Honnali Taluk, Shimoga District.

Fig. 29. River terraces and gravels washed for gold. Near Hunjankere, Mysore District.

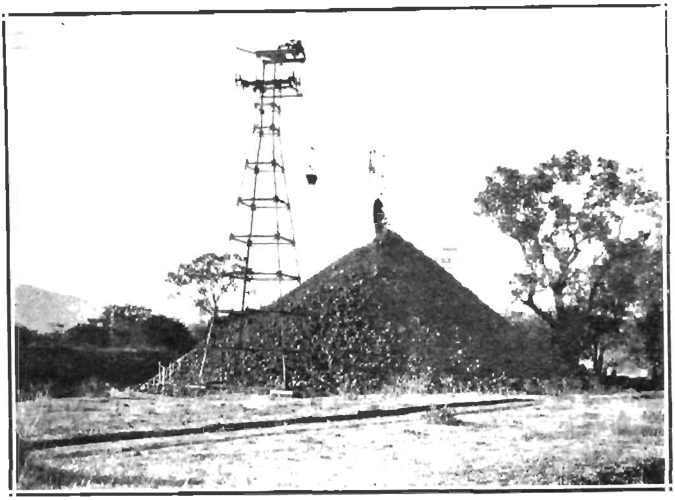


Fig. 30. Iron ore transported from Kemmangundi mines, through aerial ropeway, and dumped at the lower terminus, Tanigebail.

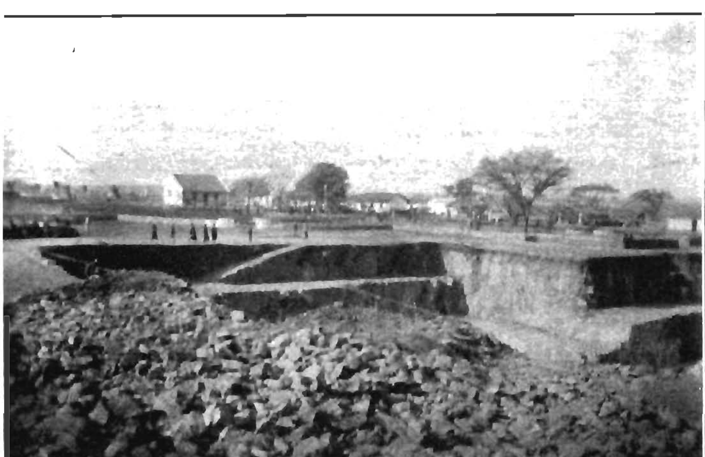


Fig. 31. Workings and ore stacks. Government Chrome Mines, Byrapur, Hassan District.

n found to be gold bearing, though at present re are no productive mines on any of them. ar Honnali, layers of sand and gravel, in the nga-Bhadra river and its tributaries, contain all particles of alluvial gold; and it is from one these, a nugget, weighing about $4\frac{1}{2}$ ozs. (worth present Rs. 600), had been found some years k. In Mysore, alluvial gold, though widely tributed in the sandy beds of streams draining Dharwar schists (Figs. 28 and 29) does not m to occur, however, in concentrated, rich ches.

Iron Ore.—Consisting mainly of hæmatite is nd, in millions of tons, capping the Bababudan ls. The deposits near Kemmangundi are being ned and the ore is transported (Fig. 30) from ere to Bhadravati, where it is smelted for manu-turing pig iron and steel. There are several er deposits containing fairly large quantities of n ores in the Dharwar schists of other parts of ysore.

Manganese Ores.—Though not of very high ade, have been mined to the extent of 7,75,000 ns from the several deposits in the chloritic hists in the Shimoga, Chitaldrug and Tumkur stricts. There still exists large quantities of low ade ore which, owing to several disadvantages, ch as heavy cart hire, high railway freight, etc., nnot be mined and exported with profit to foreign untries in competition with similar deposits of her countries which are more favourably situated r cheaper transport.

Chrome Ore (Chromite).—Occurs in several posits in the thin band of ultrabasic rocks which ns for about 20 miles from Nuggehalli, Hassan istrict, in a N. N. W. direction towards Arsikere. here are also some good deposits, associated with e ultrabasic rocks, further south in the Mysore istrict, near Shinduvalli, Talur and their adjacent arts. Some of the deposits in the Nuggehalli belt

are of low grade, but those at Byrapur are very good and contain from 48 to 50 per cent of chromic oxide. They are being worked (Fig. 32) directly by the State Geological Department, and have already produced more than 75,000 tons of high grade ore. They may probably yield another 50,000 tons of good ore.

Ores of copper, lead, arsenic and antimony have also been found in the vicinity of Chitaldrug and at other places, but these several deposits, where they have been tested, have not been proved to be extensive.

The Dharwar System contains, in addition, many non-metallic minerals. For instance,—magnesite and asbestos are found, as veins in the altered ultrabasic rocks, in the Hassan and Mysore Districts; limestones, of several varieties, are found in very large quantities in various parts of the Shimoga and Chitaldrug schist belts. The high-calcium limestone found at Bhadigund, near Bhadravati, is being mined and utilised for the manufacture of Portland Cement, and some of the deposits of dolomitic limestones are being used as fluxes for iron smelting at Bhadravati.

The Dharwar System yields also, some of the beautiful ornamental stones of Mysore. The dark grey crystalline limestone or marble, the handsome emerald-green fuchsite-quartzite the grey potstones, which have been extensively used for intricate carving purposes in the Somnathpur (Fig. 34), Halebid and Belur temples, and the Hiriyur slabs which could be used for paving purposes, are all in the Dharwar System.

Therefore, we see that the rocks of the Dharwar System are not mere matters of abstruse scientific interest to us, but they have given us in the past untold wealth and will probably continue to enrich us for years to come, provided we learn how to make use of their contained mineral

ig. 32. Open cast mining, Government Chrome Mines, Byrapur. Hassan District.

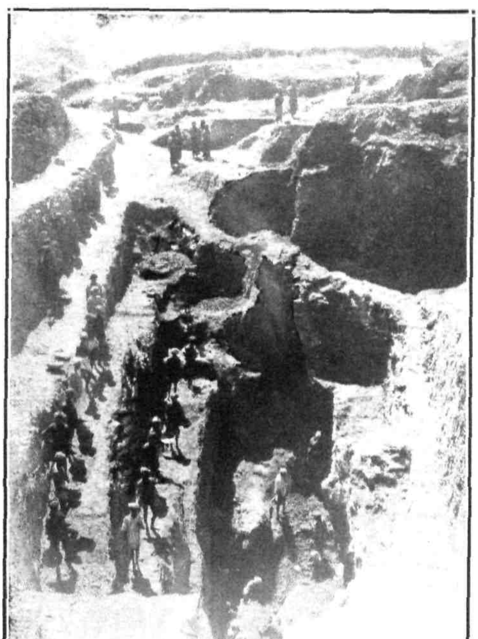


Fig. 33. Open cast mining. Government Graphite Mines, Ganacharpur, Bowringpet Taluk.

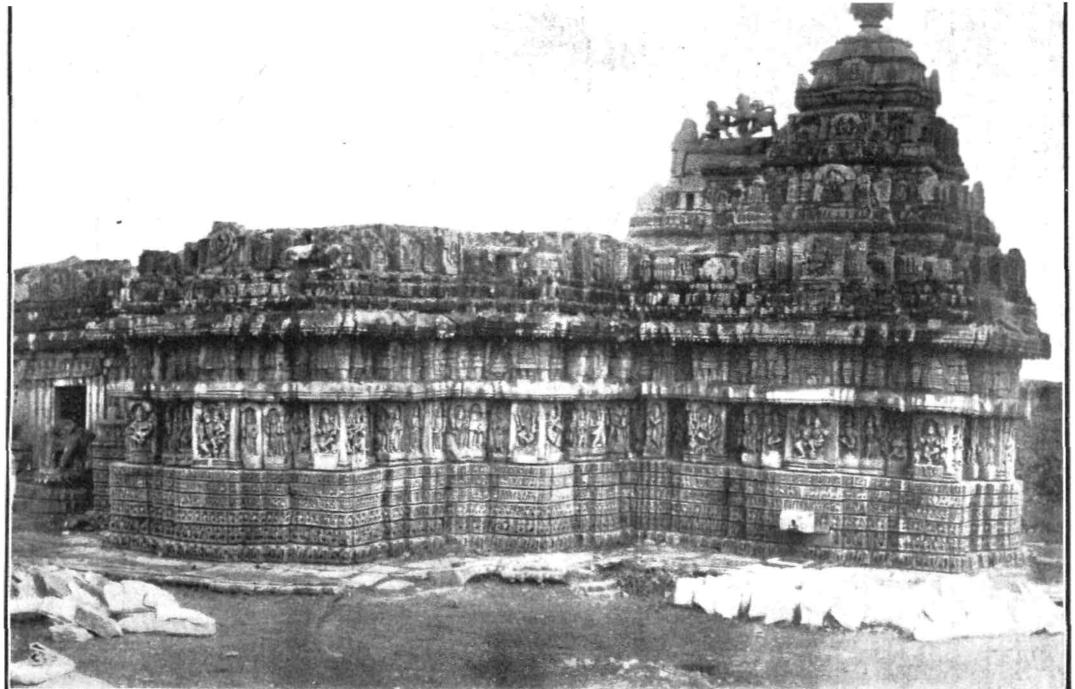


Fig. 34. Intricate carving in potstone. Mallikarjuna temple, Basaral, Mandya Taluk.

sits to the best interest and advantage of the try.

3. THE GNEISSIC COMPLEX.

With this brief account of the Dharwar System ill now turn to the vast gneissic complex h, at the present day, occupies by far the ter part of Mysore.

In the area covered by the gneissic complex ind different types of granites and granitic sses,—porphyritic granites (Fig. 35), normal ites (Fig. 37), deformed or foliated granites . 36), banded granitic gneisses and some other s which are not true granites but have become itic in appearance by later alterations. From heterogeneous complex we will first separate true granitic intrusions and consider them.

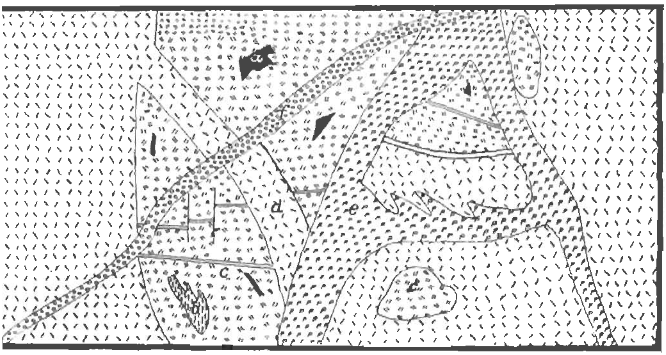
A. Granites.

Normal and foliated granites exposed in several s of this vast complex may be classified into well defined series, each representing a separate h of intrusion. The two series of granites be called for the present, the Older Granites the Younger Granites.

ler Granites.

The Older Series of Granites covers the greater part of the State and extends probably over a large portion of South India also. It consists of erent types. Some are coarse and porphyritic, ers fine and even grained; some are dark grey ight grey in colour and others pink; some are aky, banded and gneissic, and others homoge-us. Individually, all these do not form large ts and it is not necessary to describe them here letail. In many places, some of these types found mixed up into a complex. However, we distinguish, consistently, in such complexes ee or four well recognisable types, such as the

anded granitic gneiss, the coarse porphyritic neissic granite and the finer and even grained rey granite, which seem to have solidified, one fter another, with large intervals of time though ll of them, evidently, belong to one epoch of

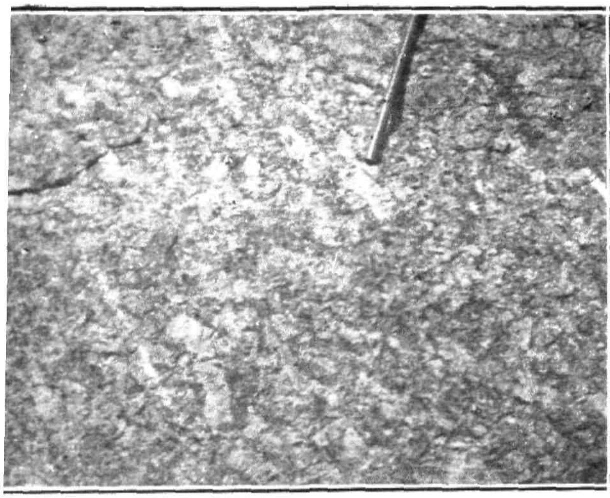


g 39. Diagram showing the relative age of different rock types in a granite complex. Dark hornblende schist, (a) of the Dharwar system and (b) a banded gneiss are both seen as included bits in (c) a coarse dark grey granite; (c) is intruded by (d) a light grey, fine grained granite; (d) is intruded by (e) a pegmatite; and (e) in turn is intruded by (f) a fine grained acid vein. From these relations we may *infer* that (a) the hornblende schist is of an older series cut out by a complex granite intrusion of which (f) the acid vein, was the last to consolidate.

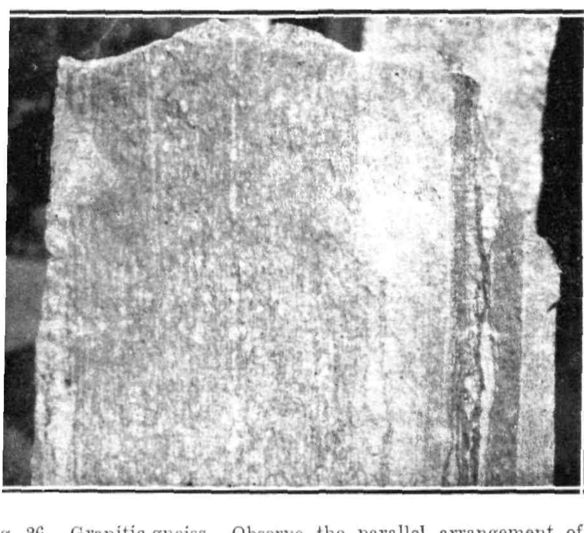
Lalbagh Quarries, Bangalore.

ıtrusion. Wherever these granites are found in rect contact with the Dharwar schists, they ıow an intrusive relation to the latter. They ıve penetrated the schists and torn them up into agments of different shapes and sizes. In any of ıe large granite quarries, which are so common all ver the State, we can readily see irregular patches, reaks and stringers of the older dark hornblende hist welded in the granites. Other members of ıe Dharwar schists, like quartzites, may also ıve been similarly torn up and incorporated in ıe granites, but due to their colour and character ing similar to the granites, they are not easily cognisable.

The granites of this series form, generally, olated rugged hills (Fig. 40), which stand out



5. Porphyritic granite. Observe the coarse felspar crystals, like the one at the end of the pencil, scattered throughout. Near Closepet.

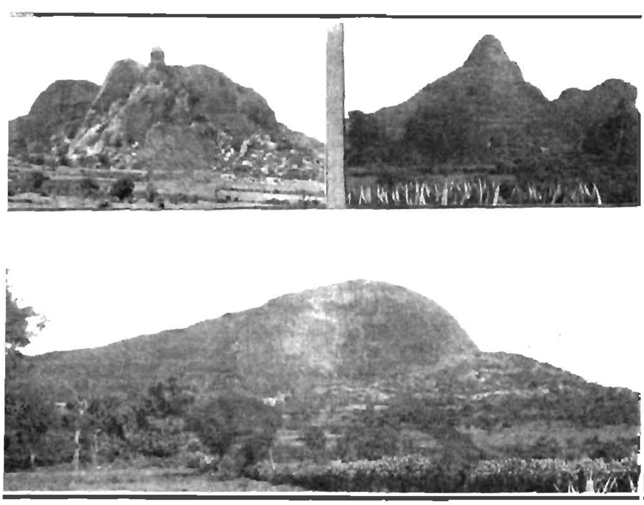


g. 36. Granitic gneiss. Observe the parallel arrangement of white felspar crystals and compare it with that of the granite of Fig. 35. Near Bangalore.

g. 37. Banded gneiss. Note the alternating bands of light coloured acid rock and the darker micaceous layers. Markonahalli, Tumkur District.

Fig. 38. Horizontal joints in granitic gneiss, which facilitate the quarrying of the rock into slabs and blocks of required dimensions. Lal-Bagh quarries, Bangalore.

. 40 Characteristic topography of "Older Granites". Note the whole hill composed of loosely piled up boulders.



g. 41. Different configurations of the "Younger Granites". Observe the conical peaks and precipitous cliffs, and the entire hills formed mainly of single gigantic boulders. Hills of the Closepet Range.

ly from the plains, or a chain of gently ting smooth hillocks. In many places they ken up into boulders and some of the hills mposed almost entirely of such boulders, piled up. In the low ground, the granites en as irregular patches or bands exposed at the surface or a few feet beneath the soil. The granites of this series have been o termed, "Peninsular Gneiss," but since gneissic area of Peninsular India, there are number of other rocks which may not have ted as granites, we need not adopt that The term Older Granites would serve our e

omewhat different in appearance to the series of the Older Granites considered above, there is another granitic series of considerable magnitude constitutes the Closepet range of hills. This ied, in Mysore, as the Closepet Granite. It a band of about 20 miles in width and runs hrough the middle of the State, in a north outh direction, from the Cauvery River near mudram in the south, to Molakalmuru in treme north, a distance of over 200 miles. oly it extends much further, both north and into the adjoining British territory. It has ing appearance in the landscape forming a of rounded hills, many of which are almost nade up entirely of single gigantic boulders. of the hills are conical, but many are flat at p with precipitous, steep sides (Fig. 41). onspicuous among such hills are those of pet, Savandurga, Sivaganga, Devarayadurga, ugiri and Pavgada. This series also forms a ex but consists, in the main, of coarse granites ning large platey crystals of shining pink or felspars. There are also some finer grained which contain pink porphyritic felspars. At argins or where they are intermingled with

r Granites.

older gneisses, the Closepet granites are deformed, banded and gneissic in appearance. In spite of this complexity, the series, as a whole, has got its distinguishing characteristics, and it forms a clearly marked intrusion of a separate epoch later than that of the Older Granites.

Outside the zone forming the continuous chain of this series, there are some other isolated masses forming the Hosdurga hills, the Arsikere and Banavar hill ranges, the Chamundi hill, and some low hills to the south of Heggaddevankote, which are very like in appearance to the Closepet granite and may belong to the same age. Round about the Arsikere and Banavar hills are found acid dykes, forming probably the offshoots of those granitic masses. In the Seringapatam and Mandya Taluks there are numerous dykes of porphyry and felsite which are believed to be connected with the intrusive epoch of these younger granites. They yield a large variety of the most handsome and ornamental building stones found in the State.

B. Granitic Gneisses.

Champion Gneiss.

At the eastern edge of the Kolar schist belt is a zone of a fine grained, gritty, micaceous gneiss containing some bands of a normal granite. It is suggested that this micaceous gneiss is a highly crushed phase of a very ancient granite which intruded the Dharwar System, even earlier than the Older Granites we have already considered. It is also believed that this very ancient 'granite' gave rise to the auriferous reefs of the Champion lode of the Kolar Gold Field, and hence has been termed "*Champion Gneiss.*" The micaceous gneiss contains grains or blebs of opalescent quartz with a characteristic colour varying from a milky blue to dark grey. In the Shimoga schist belt, there are some patches of micaceous gneisses and

›lcanic rocks which contain blebs of similar
;ent quartz, and they are found to be true
ırs of the Dharwar System. It is doubtful
micaceous gneiss bordering the Kolar schist
in any way, different to them and since we
t certain that it actually is a crushed granite,
d not separate it from the gneissic complex
anitic intrusion of any earlier epoch than
der Granites.

ckite.

orming the Biligirirangan range of hills and also the high ground to the west of Periyapatna, on the Coorg Frontier, are some gneissic rocks which differ nuch in appearance from the granites and es we have till now considered. They form p by themselves and vary considerably in sition, ranging from acid to ultrabasic types. ıre all dark coloured and invariably contain neral, hypersthene. Larger bodies of similar ıre found to the south of Mysore, forming evaroy, the Nilgiri and the Palni hills. A d account of this interesting series was given,), by T. H. Holland (now Sir Thomas) who d the several types into a single family—*Charnockite series.* He considered the ers of the Charnockite series to be igneous gin, and as products of differentiation of a magma which intruded the older granitic es.

rom our recent studies in Mysore, of the ockite rocks, we think, however, that the . members of the series do not form normal s rocks solidified as the split up portions of rticular magma as conceived by Sir Thomas ıd, but constitute a complex series of rocks, ›ably different periods, which, having been up and very highly altered, have given rise series. Rocks very similar to the Charnocre found in South Africa, Australia and some parts of the world, and the geologists who

have studied them, also believe that they are not normal igneous rocks.

From this accout of the great gneissic complex, we see, therefore, that we can distinguish in it granitic intrusions of two different epochs. There are also two other series of granitic gneisses which have certain distinguishing characters but these do not seem to have formed as typical granitic intrusions. It will be sufficient for our present purpose if we realise, that in the Mysore Archæan Complex, the Dharwar System forms the oldest recognisable group and that this has been intruded from below by two sets of granitic rocks of different ages; and these, with some other doubtful members, constitute the great Archæan Complex of Mysore.

C. Economic value of Granites.

Slabs of different dimensions are being quarried (Fig. 38) from the several types of these granites and granitic gneisses in various parts of the State. Some of the grey, fine grained, uniform granites are largely used for pillars, pedestals and for other architectural purposes (Figs. 44 and 45). Of late, kerbs and memorial stones made out of some of these varieties of granite are being largely exported to England. Since 1933, about 27,000 tons of these kerbstones and memorial stones, dressed from the granites quarried from Sarakki and other places near Bangalore, have been exported. The finer grained varieties adapt themselves very well for sculptural purposes. The far-famed, beautiful image of Gomatesvara (Fig. 43) at Sravanabelagola, carved from a single boulder of fine grained, light grey granite, shows what could be done out of these stones; and the fact that the image has very well withstood the buffettings of wind, weather and rain during these 1,000 years, since it was carved, bears ample testimony to the wearing qualities of some of these granites.

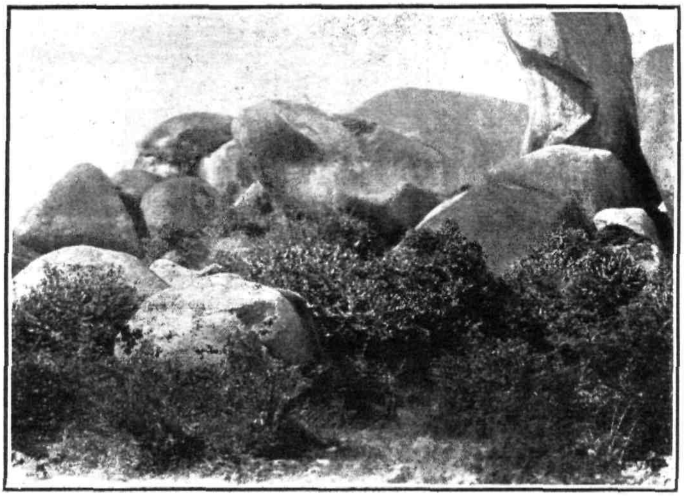


Fig. 42. Granite boulders (tors) formed by weathering along wide spaced joints. Near Chitaldrug.

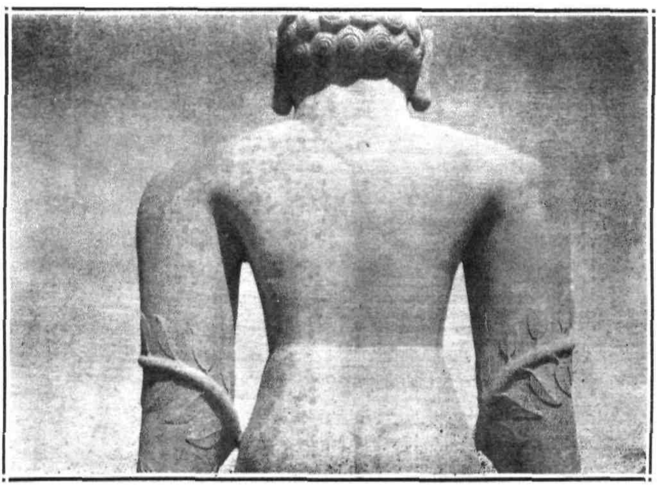


Fig. 43. A Granite image, carved from a single boulder, showing on the left side patches of pitted surface formed due to natural weathering. Note how the stone lends itself to fine carving. Gomatesvara image, Sravanabelagola, Hassan District.

Fig. 44. Monolithic Umbrella carved from a fine grained granite. Gavipur temple, Bangalore.

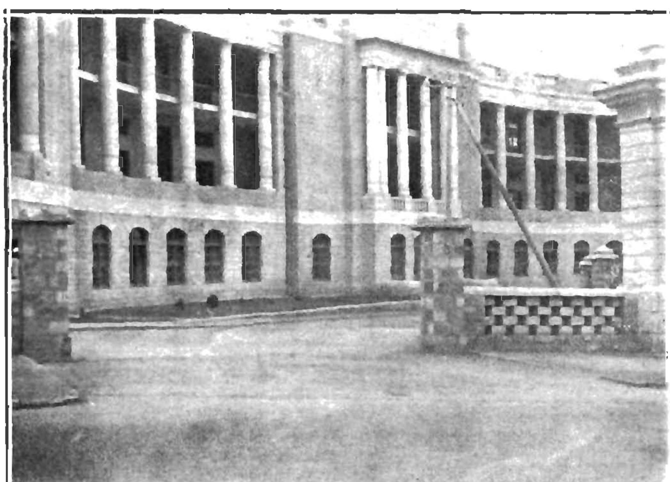


Fig. 45. A granite building; composed of granite pillars, granite walls, granite basement, etc. Technological Institute, Bangalore.

When cut and polished some of the pink coloured varieties of granite, yield handsome stones suitable for decorative purposes.

In the granites and gneisses are found the pegmatites from which we get quartz, felspar and china clay (kaolin) and all these, mined from different deposits near Bangalore, are being used by the Government Porcelain Factory for the manufacture of high tension insulators and other ceramic products. Fire clays, of different varieties, are being mined for the manufacture of stoneware pipes, fire bricks, etc. It is likely that the quartz and felspar will be used, in the near future, for glass manufacture. Mica is another important mineral which is obtained from some of the pegmatites in the State.

Granites by themselves have not given us any valuable metalliferous deposits, but the gold bearing quartz veins, like those of the Kolar Gold Field and other parts of Mysore, are believed to be genetically connected with the oldest granitic instrusion into the Dharwar schists.

4. DYKE ROCKS.

Traversing the gneissic region are found swarms of dykes which are prominently noticeable at the following three centres :—

(1) *Hornblende Dykes.*—In the Channarayapatna and Hole-Narsipur Taluks, of the Hassan District, is a swarm of dark hornblende dykes which, when viewed under the microscope, are almost similar in appearance to the dark hornblende schist of the Dharwar System. They traverse the gneissic region generally in an east and west direction, and are believed to be later in age than the granites and gneisses (Peninsular gneiss).

(2) *Norite Dykes.*—To the south of Kaglipur, Bangalore Taluk, is another swarm which consists, mainly, of dykes of norite containing the mineral

hypersthene. These dykes are generally north and south.

(3) *Felsite and Porphyry Dykes.*—Round about Arakere in the Seringapatam Taluk, is the third swarm which consists of dykes of acid rocks, like felsites and porphyries. The disposition of the dykes in this region forms more or less a broad circle. There is a similar set of dykes near Arsikere and Banavar. These several dykes of acid rocks, cut across the granitic gneisses and also the younger Closepet granites, and therefore have been formed subsequent to the intrusion of the latter, though perhaps they belong to the same period of intrusion as the Closepet granites.

IV. Post Archæan Rocks.

Dolerites.—Subseqent to the formation and folding of the Archæan Complex, the whole country has been invaded once more by a series of basic dykes—chiefly dolerite—which from their freshness and absence of deformation are regarded as post-Archæan, and it has been suggested that they may be of the Cuddapah age (Figs. 48 and 49).

Laterite.—The only other rock formation, in Mysore, of any large extent, is laterite which is of comparatively recent formation and forms a horizontal capping on the upturned edges of the folded and worn out Archæan rocks (Figs. 50 and 51). It is mainly an alteration product of the underlying rocks, but the subject of its origin and classification is too complex to be treated here. The laterite is not of any great economic value, but in the Malnad regions, where it is largely found, it is cut into bricks and used for buildings. It is rather soft while cut, but hardens considerably on exposure. Laterite forms also a good road metal. The highly aluminous variety, capable of furnishing good aluminium ore (bauxite), is rare in Mysore.

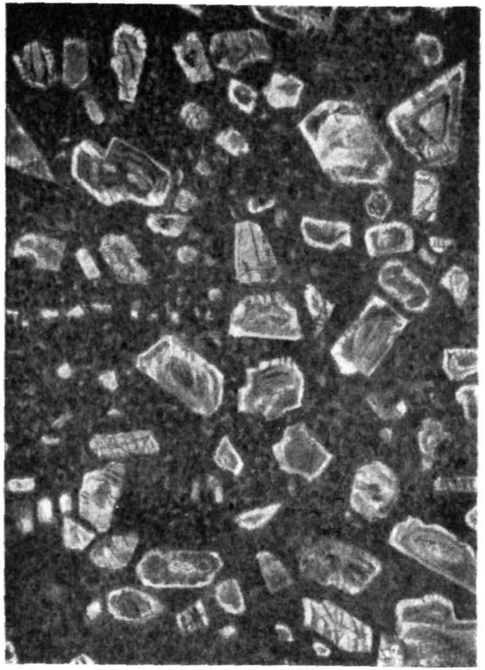


Fig. 46. Porphyry showing coarse felspars in a compact base (matrix).

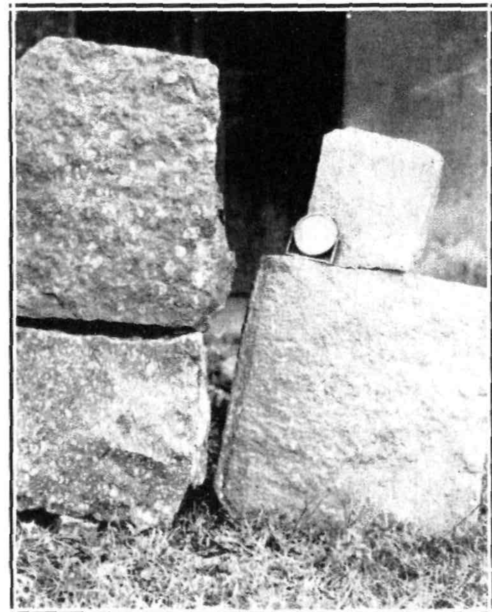


Fig. 47. Porphyries of different types.

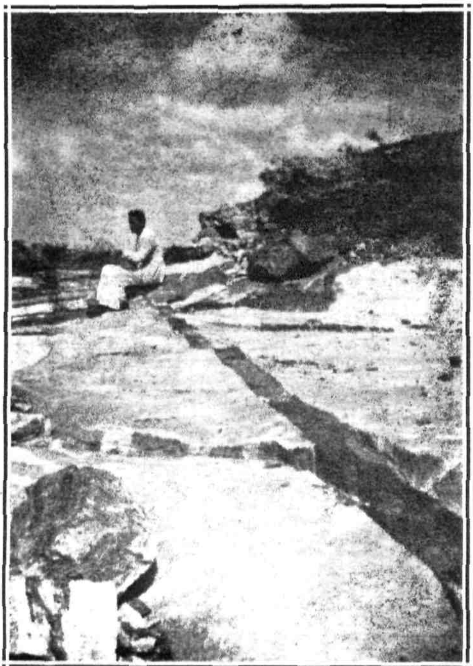


Fig. 48. Dolerite dyke (black band) cutting through the granitic gneiss. Near Bangalore.

Fig. 49. Spheroidal weathering of dyke. Observe the outer layers peeling out like the coats of an onion.

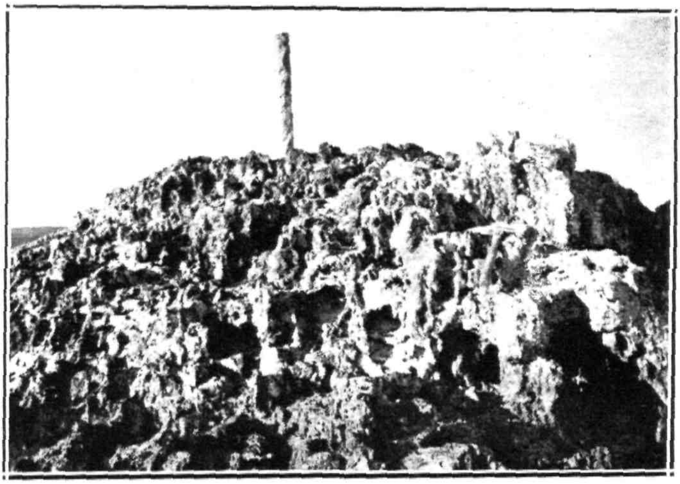


Fig. 50. Laterite hill. Nandagudi, Hoskote Taluk, Bangalore.

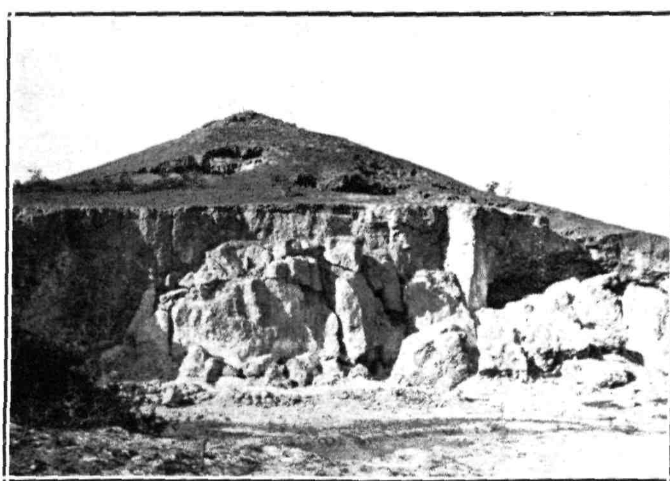


Fig. 51. Laterite hill capping, and protecting from erosion, kaolin deposits. Near Nandagudi.

Tabular view of the Mysore Rock Formations.

The several rock formations of the Mysore Plateau, which have been described in the previous pages may now be arranged in their order of formation as shown in the following tabular statement :—

Age / System	Division	No.	*Original Formations.*	*Probable Alterations.*
Probably Tertiary		12.	Recent soils and gravels ...	...
		11.	Laterite ...	...
Pre-Cambrian		10.	Basic dykes, chiefly dolerite. Bhima & Kaladgi sediments	Cuddapah age ...
ARCHÆAN		9.	Felsite and Porphyry dykes ...	...
		8.	Closepet granite series ...	Slightly foliated.
			Formation of the Charnockite series—	
		7.	Norite dykes ...	...
		6.	Hornblende dykes ...	Slightly crushed and structurally altered into granulite dykes.
			Peninsular Gneiss : Complex granitic gneisses——	
Dharwar system	Upper division	5.	Some ferruginous and cherty silts, clays, calcareous silts and clays, impure quartzites and conglomerates. —(Local).	Somewhat crushed, but otherwise easily recognisable.
	Middle division	4.	Granite porphyry and some granites, fine and coarse.	Micaceous granitic gneisses and crushed foliated gneissic granites.
		3.	Iron stones, limestones, argillites, quartzites and conglomerates— and also ashes, tuffs and other volcanic products. Basic and ultrabasic intrusives.	Banded iron stones with amphiboles, etc., granular crystalline limestones, quartzites, schistose conglomerates ; all highly crushed and crystalline.
	Lower division	2.	Rhyolites, Felsites and quartz prophyry and other acid volcanic rocks with opalescent quartz.	Quartz schists, micaceous quartz schists and gneisses with opalescent quartz, highly crushed.
		1.	Basic volcanic flows and dykes.	Green stones, Hornblende schists, etc.

V. Geological History.

With the foregoing brief account of the several rock formations of the Mysore plateau, let us now try to visualise and re-construct its past geological history. We cannot penetrate sufficiently far into the hoary past to ascertain with any definiteness

the exact conditions which prevailed over this portion of the earth, or trace the correct configuration of land and water in those unknown times. However, very many million years back, during that dim remote period when the earth had not yet seen the dawn of life, there occurred a tremendous outburst of volcanic energy. Through numerous fissures in different parts of the earth's crust welled out liquid lava which, flowing over land and water alike, covered a vast surface. What exactly was the extent of the surface so covered we cannot say, but at least it comprised all the area which we now know as Southern India. These lavas were of a basic composition and the material left behind in the fissures through which they welled out, congealed to form wall like masses of basic dykes. A long while after, over a limited portion of the ground covered by these hardened basic lavas, were poured out, again, to a less extent, comparatively thin flows of fresh lavas of a more acidic composition. It is possible that these acid lavas were erupted through volcanic vents in the neighbourhood of shallow stretches of water.

Under a hot moist climate, these rocks underwent a rapid chemical decay. The debris, formed from their decomposition and disintegration, conveyed not very far from their source was thrown down as primitive sediments in the shallow stretches of water surrounding the land areas of those days. The traces of those early sediments we now detect, with considerable difficulty, in certain parts of the Shimoga and Chitaldrug belts of the Dharwar schists. We cannot, as yet, probe further and ascertain clearly the exact conditions under which the limestones and the banded iron stones were deposited; and also the extent, depth and nature of the basins in which these various sediments were so formed. Concurrent with this sedimentation, there were also intermittent stages of volcanic activity.

The sedimentation was interrupted by the uplift of the floors of these ancient shallow basins, at about the end of the Dharwar period, and during this process of uplift, the volcanic rocks and their associated sediments got highly crumpled and corrugated ; and were rendered crystalline and schistose. A series of granitic rocks propelled from the interior of the earth penetrated irregularly, into the base of these folded schists and by diverse processes have altered them almost beyond recognition converting the schists into banded gneisses ; the sediments, into pseudo igneous types and so on. After a long interval, there was again a further disturbance caused by the intrusion of the granitic rocks of the Closepet range which induced, in their vicinity, re-crystallisation and development of new minerals, in the already altered older crystalline schists. From the effects of this granitic intrusion, the older schists were re-constructed into several interesting rocks, including perhaps some of the types of the charnockite group.

At the end of the Archæan times, Mysore, with its corrugated Dharwar schists underlain by a complex series of several granites, formed part of an extensive land mass. It must have been then a most uninviting stretch of barren ground with a monotonous dull coloured landscape, unrelieved by any bright patches of vegetation, and oppressively silent without a single animal to disturb its sombre solitude.

However, this portion of the land has never been under water since then, and consequently never received any marine sediments of later ages. Except for the intrusion of some small basic dykes of a later age (Cuddapah age), the chronological history of the Mysore rock formations had been all but completed by the end of the Archæan times, millions of years before the period of appearance of the exuberant plant growth which gave rise later to the coal formations of India. It can, doubtless,

now be realised why we cannot find coal in Mysore and how very useless it would be to hanker after it, though no doubt we would have been all the better for the possession of a few coal seams here.

From the end of the Archæan times, this land has stood like a buttress subjected only to subærial denudation. The various destructive agencies have been acting, since then, undisturbed, upon this terrain of Archæan land in wearing it down to the present landscape with its diverse beautiful bits of scenery of which Mysore is justly proud. From the Dharwar rocks have been carved out the magnificent, crescent shaped range of the Bababudan hills which stand like the lip of a gigantic crater overlooking the Jagar valley; and from the granites, fantastic isolated blocks or congeries of beautifully piled up bouldery tors. From the gneisses have been carved the beautiful Biligirirangan hill range and the Gopalaswamy hills, and also some tremendous gorges, such as the one near Sivasamudram into which the Cauvery leaps from Ganganachukke, or that, into which the Sharavati hurtles down (Figs. 60—63) from the stupendous rocky ledge of Gersoppa. Galleries and caves (Fig. 56), natural arches (Fig. 57) and bridges, cradle rocks (Fig. 53) and balancing blocks (Fig. 54), found in the several granite and gneissic hills of Mysore, are all the handiworks of nature's denuding agents.

In the absence of catastrophic changes, the present land surface will continue to be worn down by the action of wind and weather, rain, river and floods, till it is reduced to a monotonous dead level plain and that will take some millions of years and we will not happily be alive to mourn over it.

The geological processes have not rest content merely in giving us these beautiful bits of scenery. In some places, they have brought together valuable minerals which would have been otherwise too

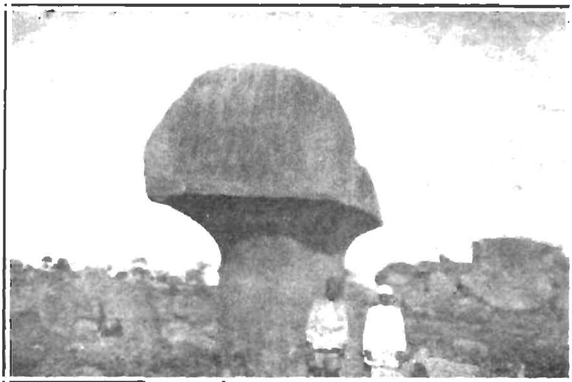


Fig. 52. Granite block, undercut, by wind erosion, into the shape of a huge Mushroom. Near Ganacharpur, Bowringpet Taluk

Fig. 53. Cradle rock formed by weathering of a coarse granite block. Near Closepet.

Fig. 54. Balancing block. Weathered along curving joints, the granite block has formed into two huge boulders: the top one resting perilously balanced on the lower one. Hebbal, near Bangalore.

Fig. 55. Gneissic block undercut, by wind and weather, into the shape of a cobra's hood. Hebbal, near Bangalore.

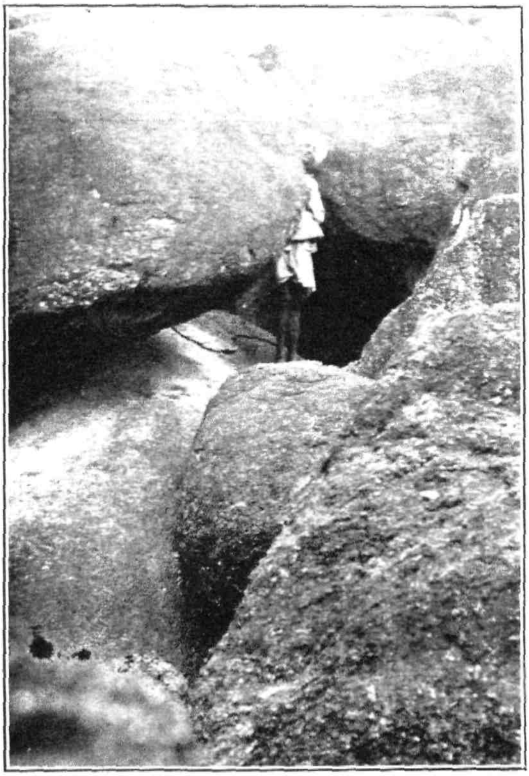


Fig. 56. Gallery and cave formed in a coarse granite. The cave is formed due to the scouring out of softer *inclusions*.

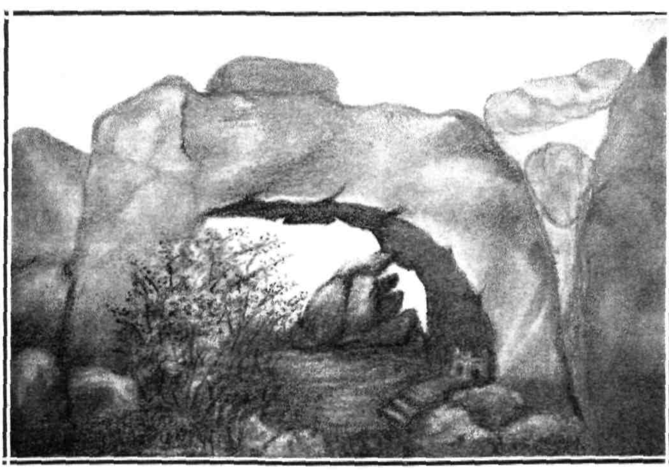


Fig. 57. Natural Arch, formed by weathering, in a fissile gneiss. The arch known as "Bhimankandi", is about a hundred feet in span, 40 feet in height and 50 feet wide; and is perched on the top of a steep hill, most unsuitably situated for a photograph. Near Goravanpur, north of Halagur, Malvalli Taluk.

Fig. 58. A deep, narrow valley formed, from the rapid erosion of a basic dyke, in a highly resistent quartzite. Dod-Byadarhalli, near French-Rocks.

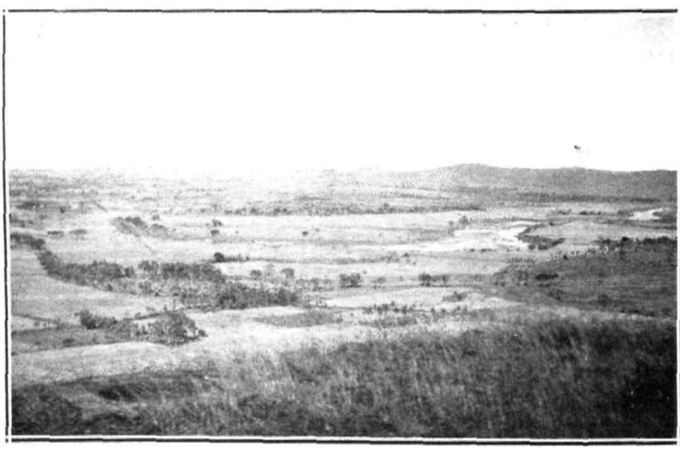


Fig. 59. A wide valley in the gneissic plain formed by the meandering of the river Hemavathi. In the background are the hills of the Dharwar schists at the base of which the river winds northwards. Looking North from Yennehole-Ranganbetta, Hole-Narsipur.

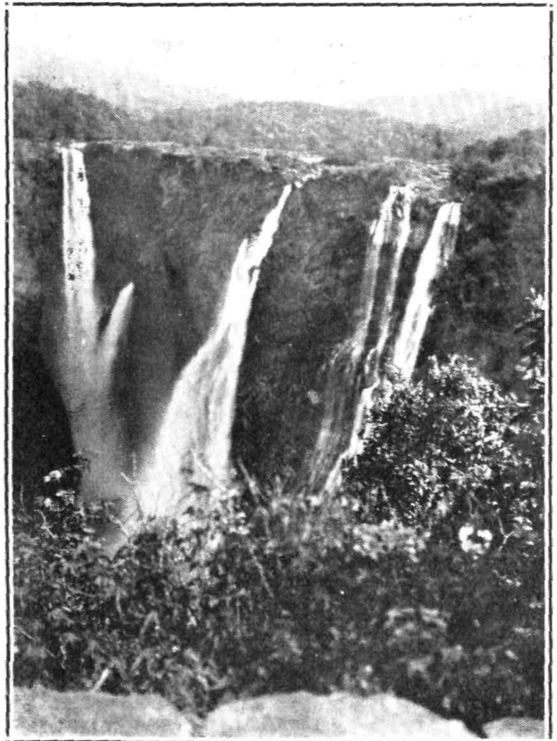


Fig. 60. A general view of the Gersoppa (Jog) falls. From left to right they are—the Raja, the Roarer, the Rocket and the Dame Blanche. The falls are formed in a highly jointed granitic gneiss which dips upstream. View from the Mysore side.

Fig. 61. The Roarer rushing through a transverse joint plane before leaping to mingle with the Raja fall. View from the Bombay side.

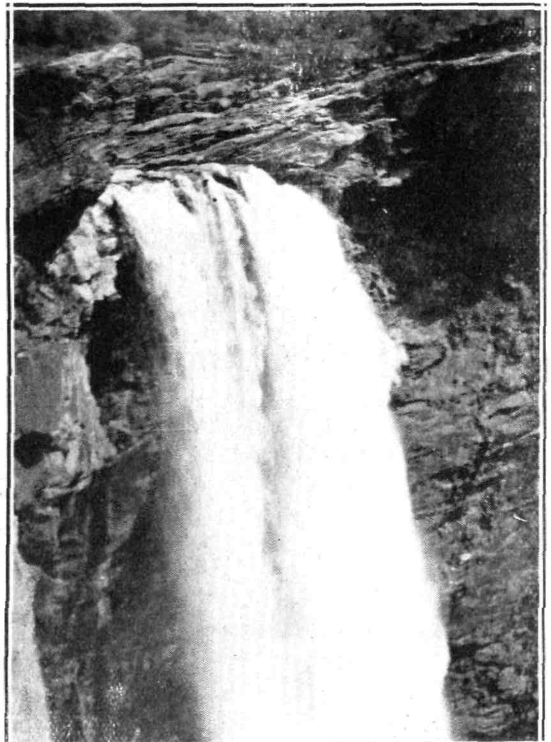


Fig. 62. A near view of the Raja fall which hurls down 830 feet in an unbroken, single column. View from the Bombay side.

Fig. 63 The Sharavati gorge, some distance below the falls.

Thin sections of rocks as seen under the Microscope.

Fig. 64. Diorite (A basic plutonic igneous rock). Note the minerals are all coarse. The white ones are quartz and felspar, and the fractured mineral at the top is hornblende.

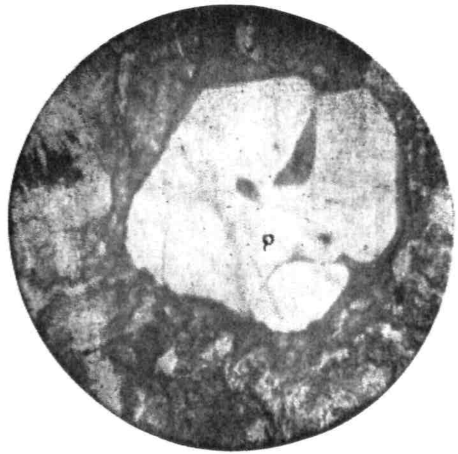


Fig. 65. Quartz porphyry (An acid dyke rock). Note the coarse crystal of corroded quartz in a fine grained groundmass.

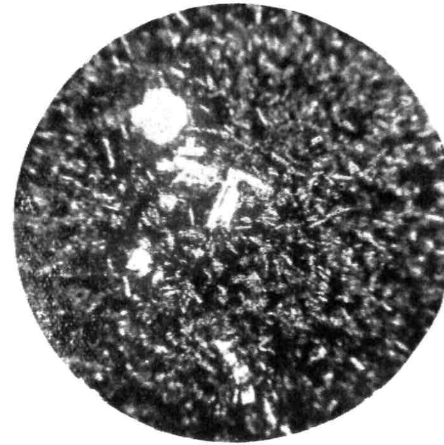
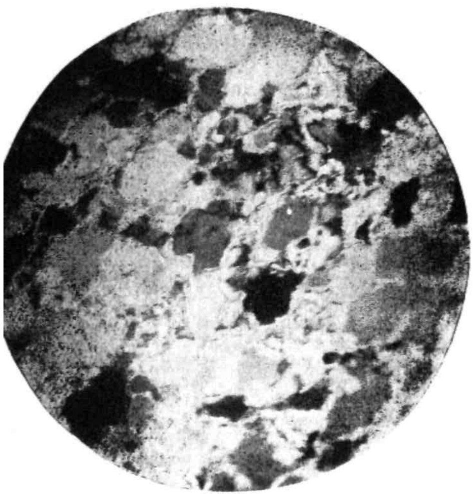


Fig. 66. Basalt (A basic lava). Note the compact structure. There are a few crystals of felspar scattered about.



ig. 67. Quartzite. Note the quartz grains still showing their original rounded nature though considerably masked by re-crystallisation.

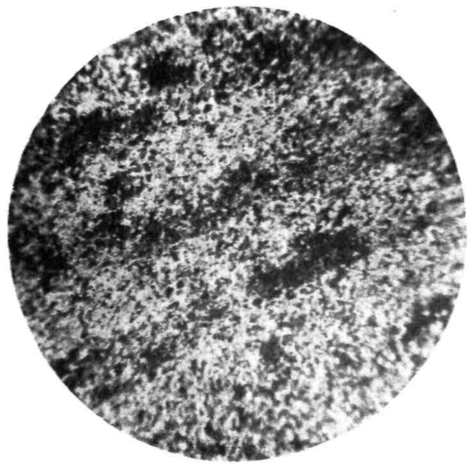


Fig. 68. Clay stone. An altered, re-crystallised clay stone. Note its fine texture and traces of original banding.

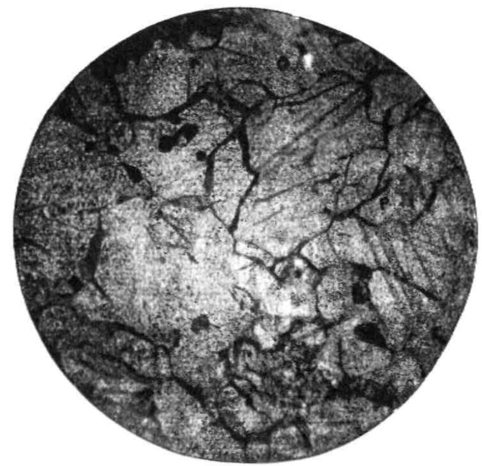


Fig. 69. Crystalline limestone; Consists mostly of coarse calcite crystals.

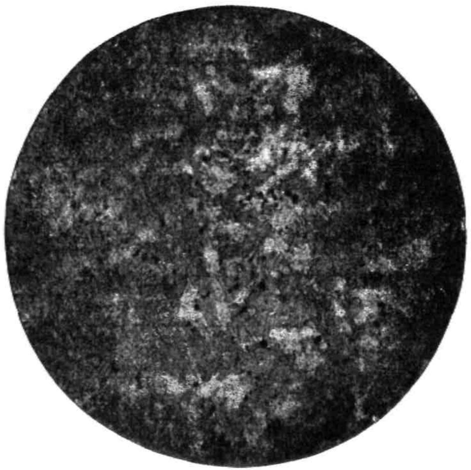


Fig. 70. Hornblende schist (Dharwar). Note the lath-shaped felspars indicating the igneous origin of the rock.

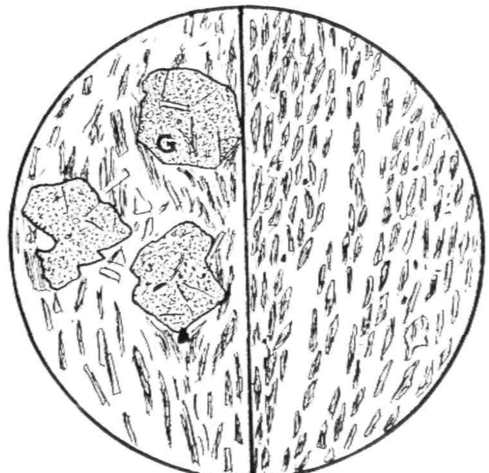


Fig. 71. Mica-Chlorite Schist. Note the parallel arrangement of the flakey minerals. In the left half are coarse grains of garnets also.

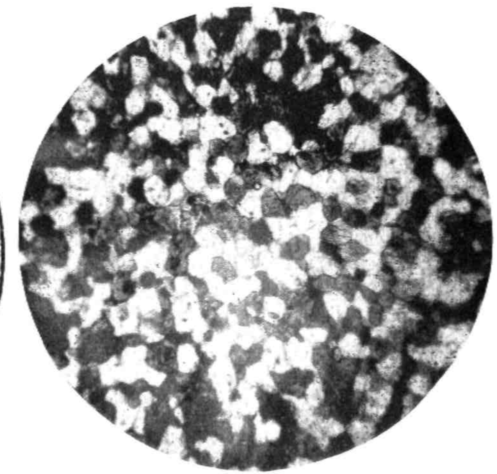


Fig. 72. Granulite. Note that all the minerals are more or less evenly granular.

sparse to be of any practical use; and in other places, by removing useless portions—in solutions or otherwise—have enriched their quality. At some places they have brought the deposits deeply buried, very near the surface, and at others, for those which are still hidden underground, they have created clues by which a trained geologist can easily detect them. By decomposing, they have rendered some minerals, which might not have been of any practical use, into others, which are of considerable value. In such ways, the geological processes have aided in distributing, in several parts of the Mysore State, mineral wealth to the tune of at least a few hundred crores of rupees. We cannot find space here for a detailed description of these several processes.

It is intended, however, to publish hereafter, in this series of popular studies, other booklets, each one dealing specially with some interesting feature relating to the Geology of Mysore or its mineral resources. Interested readers, who desire more information on any of these, may kindly consult those books, when published.

VI. GLOSSARY.

1. ROCKS AND ROCK STRUCTURES.

Acid.—In petrography, this term is applied generally to igneous rocks which contain more than 66 per cent of silica.

Agglomerate.—An assemblage of coarse angular fragmental volcanic rock materials.

Alluvium.—Deposits laid down in flood plains.

Aplite.—A fine grained rock which consists mainly of quartz and felspar. It occurs as veins in granites.

Aqueous Rocks.—Sedimentary or chemical deposits formed under water.

Arenaceous.—Composed of sand, loose or cemented.

Argillaceous.—Composed mainly of clay ormud.

Argillite.—A compact clay or mudstone cemented by silica.

Ash (Volcanic).—Fine grained rock material composed of very small bits of hardened lava, uncrystallised glass, minute crystals, etc., ejected by volcanoes.

Autoclastic.—A term applied to rocks that have been shattered or crushed in place, by mechanical processes, into angular or sub-angular bits. Some of the conglomerates of Mysore are of this type.

Banded Gneiss.—A foliated granitic rock which shows layers of acidic material (quartz and felspar) alternating with layers composed of dark coloured minerals.

Basalt.—A compact, dark rock—often vescicular and porphyritic—consolidated from a basic lava flow.

Basic.—A term applied to igneous rocks which have a low percentage of silica, ranging from 44 to 52 per cent.

Batholith.—A large mass of igneous material which, intruding its overlying formation and cutting across it, has consolidated at great depths from the surface. Granite, diorite, etc., occur as batholiths.

Bedding.—Layering or stratification produced during the deposition of sediments due to slight variations in character, composition or weight of the transported material.

Breccia.—A consolidated debris of coarse angular or sub-angular fragments of rock, of varied or uniform composition.

Charnockite.—A granular variety of hypersthene granite in which even quartz and felspar, which would be normally light coloured, are dark grey or bluish grey in tinge.

Charnockite Series.—A series of rocks, ranging in composition from a typical acidic granite to basic and even ultrabasic types, all characterised by a granulitic texture and the presence of hypersthene. They are found, typically, forming the Shevoroys, Nilgiris and some other hill ranges of Southern India and also the Biligirirangan range of hills in Mysore.

Chert.—A compact, more or less, pure siliceous rock composed mainly of fibrous or radial non-crystalline silica with or without the remains of siliceous skeletons of minute organisms.

Clastic.—A term applied to rocks composed of fragmental material derived from pre-existing rocks.

Conglomerate.—A sedimentary rock composed of rounded pebbles or gravel held together in some cementingmatrix.

Crush-Conglomerate.—A conglomerate in which the pebbles have been drawn out, broken or crushed, due to pressure. Severe crumpling and crushing may produce a false conglomeratic appearance in complex igneous rocks also, if they are composed of portions of varying strength. Autoclastic, crush-conglomerates of the latter type are

very common in ancient rock formations like those of Mysore, and they need careful separation from the crushed, true conglomerates.

Current Bedding.—A structure generally found in arenaceous rocks in which the planes of minor laminations are inclined or lie obliquely to the larger main bedding planes. The structure is mainly developed in the shallow water, shore line and deltaic deposits, and also in deposits formed through the agency of wind. Each type has its distinctive characteristics and, when present in ancient rock formations, furnishes a clue to the precise mode in which those rocks were formed.

Denudation.—The process of destruction of land areas by disintegration and transport through wind, weather, rain, running water, waves, snow, ice and glaciers, and similar other agencies.

Dip.—The inclination of the tilted or folded strata to the horizontal plane.

Dolerite.– A coarse to fine grained, dark coloured basic dyke which may be, sometimes, porphyritic.

Dolomite.—A mineral in which the carbonates of lime and magnesia are found to be in equal proportions. The term is also applied to rock masses of that composition.

Dolomitic Limestone.--A limestone containing dolomite, but in which lime carbonate is dominant over magnesian carbonate.

Dyke.—An igneous rock which consolidates under shallow depths and cuts across the bedding or foliation of the invaded formations. It is, generally, many times longer than its breadth, and stands out on weathering like a long ruined wall or, as noticeable in many parts of Mysore, like a row of dark boulders.

Epidiorite.—A dolerite or basaltic rock in which the augite has altered to hornblende.

Erosion.—The cutting down of channels by running waters, like streams and rivers.

Fault.—A dislocation of strata formed by fracturing and displacement, during severe crumpling and folding resulting from earth movements.

Felsite.—A compact, light coloured or grey, acid rock occurring usually as a dyke.

Ferruginous.—Containing iron, or its compounds.

Folds.—The tilting, arching up or crumpling of the horizontal strata as an effect of earth movement.

Fossil.—The harder structures, skeletons, bonts and other relics of ancient animals and planes preserved in rocky strata.

Gabbro.—A plutonic basic rock, dark coloured and coarse grained. (Consists of augite and plagioclase felspar).

Gneiss.—A foliated granite or diorite, or rocks of that mineral composition, in which platey minerals like felspar, black mica and hornblende are drawn out and show roughly parallel or lenticular disposition. The banded gneisses consist of parallel or lenticular layers of quartz and felspar alternating with layers composed mostly of dark coloured minerals.

Granite.—A plutonic acid rock consisting mainly of quartz, potash felspar and black mica. In colour, it may vary from light grey to dark grey, or from pink to reddish. Some types may be uniform and fine grained, and others, coarse having large, shining plates of felspar crystals.

Granulite.—A metamorphic rock in which all the minerals are, more or less, evenly granular.

Greenstone.—A field term applied to all altered basic igneous rocks, such as dolerite, basalt or gabbro.

Igneous rocks.—Rocks, which consolidate from fused or molten material, like lavas, porphyries, granites, etc. They are massive and unstratified.

Iron stone.—Rock masses consisting mainly of iron oxides or carbonates usually formed by chemical precipitation under water. Banded iron-stone, like the one so conspicuously seen among the Dharwar Schists, consists of thin layers of dark

brown iron oxides (hæmatite or magnetite) alternating with white layers composed mainly of quartz; very often contorted into most complicated patterns.

Kankar.—A nodular, impure, lime carbonate mixed up with quartz, etc., formed from the decomposition of lime felspars. It is found as a superficial deposit in weathered rocks—like granite, ultrabasic rocks, basic dykes and also limestones.

Kaolin.—A white, pure variety of clay, known also as china clay, formed from the decomposition of felspars in pegmatites. It is generally mixed up with quartz, flakes of white mica, etc.

Laccolith.—A dome shaped igneous intrusion which, arching up its roof of invaded formation, consolidates under comparatively shallow depths from surface.

Laterite.—A residual deposit characteristically seen in the tropical regions—which consists essentially of hydrated oxides of iron and aluminium, formed from the decomposition of many kinds of rocks, by weathering and leaching out of certain constituents in solution. It is often concretionary and has long tubular cavities. When quarried it is soft, but on exposure it gets hardened. Found in Mysore, in parts of the Kolar, Bangalore and Shimoga Districts.

Lava.—The molten material which, propelled from the interior of the earth, flows over the surface through volcanic vents and fissures and consolidates as a dense glassy rock.

Limestone.—A general term for stratified rocks consisting predominantly of calcium carbonate. In rare instances, some types of limestones may also be formed by decomposition and replacement of lime bearing igneous rocks.

Magma.—A comprehensive term for the molten fluids generated in the interior of the earth from which igneous rocks are considered to have been derived and consolidated.

Metamorphism.—The alterations in mineral composition, and structure and texture produced in a rock mass when it is subjected to the action of high temperature and pressure, either as a result of an igneous intrusion or slow crumpling due to earth movements.

Norite.—A basic igneous rock which contains, essentially, hypersthene and plagioclase felspar. In the Charnockite series, it forms a conspicuous member.

Orthogneiss.—A general term applied to gneisses derived from rocks of igneous origin.

Paragneiss.—A general term applied to gneisses derived from rocks of sedimentary origin.

Pegmatite.—An acidic phase of granites which cuts across them, like veins and dykes. It consists usually of very coarse crystals of quartz and felspar, and often bunches of mica and some rare earth minerals.

Petrography.—The science which deals with the systematic descripton of rocks.

Petrology.—The science which deals with the natural history of rocks, including their origin, present condition, alterations and decay. It is wider in scope than petrography.

Phyllite.—A compact, lustrous, schistose rock derived from the alteration of clayey sediments.

Plutonic.—A general term applied to deep seated intrusions and to the rocks of which they are composed suggestive of the great depths at which they were formed. (From Pluto—God of the Underworld).

Porphyry.—An acid dyke rock which contains coarse tabular crystals of felspar scattered in a compact base.

Porphyritic texture—A texture of igneous rocks due to the presence of crystals which, having formed earlier and under slow rate of cooling, are conspicuously larger than similar minerals of the ground mass which crystallised rapidly by sudden

cooling. The coarser crystals are found sprinkled in the ground mass.

Quartzite.—An altered rock consisting mainly of grains of quartz formed usually by recrystallisation of a sandstone. Vein quartz and fine grained acid igneous rocks when crushed by earth movements produce quartzite-like rocks which are hardly distinguishable in appearance from similarly crushed true quartzites.

Quartz porphyry.—An acid dyke rock which contains coarse crystals of quartz, sprinkled in a compact ground mass consisting of quartz, felspar and usually some uncrystallised glass.

Rain print.—Shallow circular hollows formed due to the impact of rain drops on exposed layers of mud, clay and fine sand. These impressions are often found preserved in rock formations.

Rhyolite.—An acid lava or volcanic rock corresponding in chemical composition to a granite.

Ripple-mark.—A series of roughly parallel depressions or furrows and alternating ridges produced in unconsolidated sediments like fine sand, by the action of moving water. Ripple marks are usually produced by waves and currents, near shore lines. Ripple marks could also be produced in unconsolidated sand in desert regions by the action of wind. Each of these types has got its typical characteristics and therefore the presence of ripple marks in any rock formation gives a clue to its mode of origin.

Sandstone.—The term is applied to an indurated or hardened sand. It may be of different colours, soft or gritty, and coarse or fine. It consists mainly of grains of quartz, but may contain some felspar, mica, grains of iron ore, etc.

Schist.—A general term for fine grained foliated rocks usually produced by compression, in which flakes of mica, chlorite, talc, needle-like hornblende and similar other minerals are disposed lengthwise parallel to each other. Schists may be produced

by crumpling and foliation of both fine grained igneous rocks and also argillitic sedimentary rocks.

Sedimentary rocks.—The term is usually applied to rocks formed under water from the deposition of transported sediments in which lamination, bedding and stratification are characteristic features.

Shale.—A hardened, laminated, argillaceous or clayey sediment.

Sill.—A tabular sheet of igneous rock injected along the bedding planes of sedimentary or volcanic formations.

Slate.—A compact, fine grained argillitic rock which is highly fissile and splits into very thin sheets or layers along planes either vertical or highly inclined to the original planes of bedding.

Spheroidal weathering.—A kind of weathering accentuated by concentric cracks, which gives rise to boulders or rounded blocks by the peeling off of successive shells or concentric layers. This is very characteristically noticed in fine grained homogeneous basic dykes.

Strata.—A series of layers or beds characteristic of sedimentary formations.

Stratigraphy· That branch of Geology which deals with the classification, correlation and description of strata.

Strike.—The attitude or direction normal to the true dip of a bed.

Trap.—The term 'Trappa' means in old Swedish, steps or stairs. It was originally applied to igneous rocks which were neither coarsely crystalline, nor cellular and scoriaceous like lavas. Under this term are included basic rocks of widely different nature like basalts, dolerites, etc., and their altered varieties. In Mysore, this name is used for large bodies of bouldery weathering basic greenstones, epidiorites and diabases, such as those found near Santaveri, Bellara and Jogimardi.

Travertine.—A concretionary or porous limey rock precipitated from calcareous waters, usually

white or yellowish, varying in texture from a soft chalk like substance to a compact building stone.

Ultrabasic.—Term applied to igneous rocks which have their silica percentage of about 45 or less. They are heavy, dark coloured rocks and contain very little of felspar. They are the chrome bearing rocks of Mysore, and, by decomposition, have given rise to magnesite, potstone and other useful minerals.

Vein.—An infilling of fissure either by the deposition of minerals precipitated from solutions or by injection of igneous material. Veins are usually narrow, varying in width from a fraction of an inch to not more than a foot or so.

2. ROCK FORMING MINERALS FOUND IN MYSORE.

Actinolite.—A mineral of the amphibole group, grass green to bright green in colour, and long bladed to needle-like in form. Chemically it is a calcium-magnesium-iron silicate. Fibrous varieties form asbestos.

Amphiboles.—An important group of rock-forming minerals of varying chemical composition, but all having some well recognisable common characteristics. They are found in many rock types, either as dark lustrous plates or as long bladed crystals, (Fig. 73 A.) and in thin sections, seen under the microscope, they show bright colours,—bluish green,

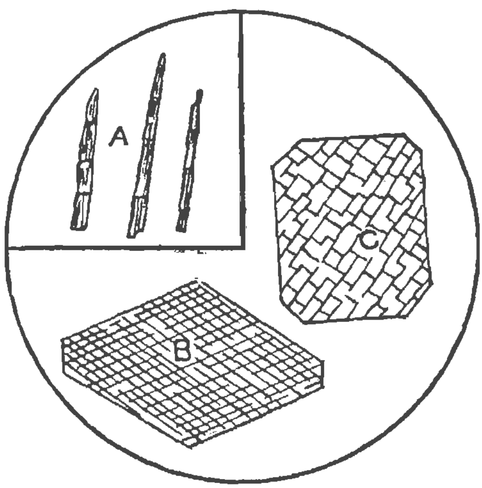


Fig. 73. Diagram showing typical sections of amphiboles and pyroxenes as seen under the microscope. A=Needle shaped amphibole. B=Amphibole (Note diamond shaped cleavages). C=Pyroxene (Note rectangular cleavages).

brown, yellow, etc., the colours differing in different directions. All have characteristic diamond shaped cleavages (Fig. 73 B.). Common hornblende, actinolite, tremolite, bababudanite and cummingtonite are some of the types found in Mysore and mentioned in this book.

Augite.—A mineral of the pyroxene group,—another important group of rock forming minerals—usually found in basic igneous and metamorphic rocks as stout crystals or grains, dark in colour. When seen under the microscope in thin sections, the mineral may be pale green, colourless or purplish. It has a characteristic rectangular cleavage (Fig. 73 C).

Bababudanite.—A new type of amphibole, discovered in 1907, occurring as needle-like crystals in the banded iron stones of the Bababudan Hills. The mineral, when seen under the microscope, shows bright colours—greenish blue and violet.

Beryl.—A very pale green or almost colourless mineral occurring as coarse crystals in six sided prisms, in some of the pegmatites of Mysore. Green and transparent varieties form the gem, emerald; but such varieties have not been found in Mysore. In composition, the mineral is a beryllium, aluminium silicate.

Biotite.—A dark or black mica found in granites and other acid igneous rocks, and also in some of the metamorphic rocks. It is dark brown in sections.

Calcite.—Chemically, it is a carbonate of lime; forms the chief constituent of the limestone. Coarse crystals are transparent. They are easily scratched with knife and effervesce with dilute acids.

Chlorite.—A soft, dull greenish mineral found as an altered product in basic igneous and metamorphic rocks. It is a hydrous magnesian silicate.

Corundum.—It is a very hard mineral, found as grains and barrel shaped crystals in metamorphic rocks. It varies in colour from different shades of

red to grey, greenish or even bluish. When coloured and transparent it forms gem stones,—ruby, sapphire, oriental emerald, etc. Chemically, it is an oxide of aluminium.

Cordierite.—A bluish grey mineral, found generally as grains in some types of metamorphic rocks. It is almost like bluish quartz in appearance. Chemically, it is a magnesium-aluminium-iron silicate.

Cummingtonite.—A veriety of amphibole, of a clove brown to dark brown colour. It occurs in bladed and needle-like forms; and in Mysore, generally in the banded iron stones of some areas, and rarely, as in the Kudurekanave area, in the ferruginous dolomitic limestones.

Epidote.—A silicate mineral of dark colour but of a peculiar greenish tint in sections, seen in many types of crystalline rocks. Along with pink felspar, it is found as veins in the granites, in the neighbourhood of the Younger Granites of Mysore.

Felspars.—A group of very important rock-forming minerals found in almost all classes of igneous rocks. They are of variable chemical composition but can be classed into two well defined groups:—(1) Potassium-aluminium silicates and (2) soda-lime-aluminium silicates. They are seen as shining plates, either white or pink in colour, in granites, diorites and other coarse grained igneous rocks. In many of the porphyries, they are found as coarse crystals scattered in a fine grained ground mass. With quartz, they occur as very coarse crystals in pegmatites.

Garnet.—A mineral usually found in metamorphic rocks like mica schist, gneiss, hornblende schist, granulite, etc. It is a complex silicate of very variable composition, and according to this variation in composition several types have been recognised. Garnets are generally of some shade of red, but sometimes they are found yellow, white,

green or even black. The transparent varieties form gem stones.

Hornblende.—A very common variety of the amphibole group. It is black in specimens, but in thin sections it is bluish green, bright green, dark brown or yellow in colour. Forms the chief constituent of hornblende schists and a prominent constituent of the traps, greenstones, and various other igneous rocks.

Hypersthene.—A mineral of the pyroxene group found usually in basic rocks, as dark grains and plates, often showing a bronzy lustre. In thin sections, shows very bright red and green colours for different directions. Forms an essential constituent of the Charnockite Series of rocks.

Kyanite.—A long, bladed, blue mineral found in the mica schists. On certain faces it shines with a pearly lustre. It is easily scratched with a knife on some faces while on others it cannot be so scratched. It is also found of a green, grey or even black colour. Chemically, it is an aluminium silicate. Found in the metamorphic rocks near Hole-Narsipur and also sparingly in similar rocks in some parts of the Mysore District.

Mica.—An important mineral found in acid igneous rocks and also in mica schists. There are several varieties of micas,—colourless and coloured, golden yellow, dark brown, green, etc. They are usually found as "books" and can be easily split up into thin flakes in which condition they are perfectly transparent.

Muscovite.—A colourless, transparent variety of mica, found very often as small scales and plates in acid igneous rocks. Found as thick books, in some of the pegmatites. It may show slight shades of pink or green.

Olivine.—Usually forms a chief constituent of ultrabasic rocks and when unaltered is found as green granular crystals. It is rarely fresh and by

alteration gives rise to serpentine, chlorite and other hydrous iron magnesian silicates.

Pyrites.—A yellow cubic mineral found in many places in chloritic schists and other metamorphic rocks. It is a sulphide of iron, and on account of its bright yellow colour very often mistaken for gold from which it is also known as fool's gold.

Pyroxenes.—An important group of rock-forming minerals, like the amphiboles, and in chemical composition the minerals of this group are similar to the corresponding ones of the amphibole group. They, however, differ from the amphiboles in some respects, the most important difference being their rectangular cleavages as opposed to the diamond shaped cleavages of the amphiboles.

Quartz.—A crystallised form of silica. It forms an essential constituent of granites and gneisses where it is seen as dull, oily lustred grains of grey, bluish grey and similar other shades. It forms conspicuous veins in granites. Sandstones and quartzites are mainly composed of this mineral. When found as coarse transparent crystals, it is known as rock crystal.

Serpentine.—A soft, oily lustred mineral of a dull apple green, yellow or brown colour. It is often found as veins in some of the ultrabasic rocks. When fibrous it forms a variety of asbestos, called Chrysotile. Chemically, it is a hydrous, magnesian silicate.

Sillimanite.—An aluminium silicate found as needle like crystals in some metamorphic rocks, like mica schists, associated with kyanite, staurolite, etc.

Staurolite.—Another conspicuous mineral in some of the metamorphic rocks like mica schists. It generally forms cross-like twins. It is black in colour and fairly hard. Chemically, it is a hydrous iron-aluminium silicate.

Tourmaline.—This is a complex boro-silicate of iron, magnesium, lithium, etc. It is usually

formed in some granitic rocks which undergo a special type of alterations during the last stages of their soldification. Though generally black and of a dull pitchy lustre—some varieties are found coloured and transparent. The mineral is also found in some of the metamorphic rocks and sands. None of the transparent coloured varieties, are found in Mysore.

Tremolite.—A variety of amphibole, just like actinolite in chemical composition and form, but does not contain any iron.

3. ORES AND ECONOMIC MINERALS FOUND IN MYSORE.

Antimony Ochre.—An earthy yellow oxide of antimony. This is found associated with antimony sulphide (stibnite) near Chikkonnanhalli, Chitaldrug.

Asbestos.—Fibrous forms of the amphiboles—actinolite, tremolite, anthophyllite, etc.—found near Hole-Narsipur. Fibrous variety of serpentine also forms asbestos and this is found as small veins in an ultrabasic rock, near Mavinhalli, Mysore District.

Bauxite.—A hydrous aluminium oxide, forms an ore of aluminium. Pure bauxite is very rare in Mysore, but highly ferruginous types are found to some extent near Sivaganga, Chitaldrug District.

Chromite.—An oxide of chromium and iron. A heavy dark mineral found as veins and thick deposits associated with ultrabasic rocks, in some parts of the Hassan and Mysore Districts. This mineral is being mined to a fairly large extent, and the Government Chrome Mines at Byrapur produce some high grade ore.

Chrysotile.—Asbestos formed from fibrous serpentine. It is found as thin veins in the ultrabasic rocks—near Mavinhalli, Mysore District, and near Hole-Narsipur, Hassan District.

Copper Ores.—Of the numerous ores of copper, the green carbonate (Malachite) is found to a small extent in quartz veins and other rocks in some parts of Mysore. In Biligere, Nanjangud Taluk, it is found associated with the red oxide of copper and at Ingaladhal, near Chitaldrug, it is found associated with the blue sulphate of copper.

Galena.—An ore of lead (Lead sulphide) occurring as heavy, cubic crystals of a lead grey or silver white colour. Occurs to a small extent in the quartz veins to the north of Chitaldrug.

Gold.—A well known precious metal. Occurs as minute grains and streaks in veins of blue quartz in the Kolar Gold Field and also in some of the veins of white quartz in other areas comprised of the Dharwar Schists. As an alluvial deposit, it is found sparsely distributed in some of the river sands and gravels.

Graphite.—Popularly known as black lead. It is a crystalline form of carbon and has nothing to do with lead. It is used for making "black lead" pencils, crucibles, foundry facings, etc. As a fine, black, earthy powder it is found in Mysore in the decomposed granitic gneiss near Ganacharpur, Bowringpet Taluk, and as coarse scales in the metamorphic rocks of the Sargur area, Mysore District. The mineral mined from the Ganacharpur deposits is being used for foundry facings at Bhadravati.

Haematite.—Red oxide of iron, forming an important ore of the metal. Large quantities are found capping the Bababudan Hills. The deposits near Kemmangundi are being mined and transported to Bhadravati for purposes of iron and steel manufacture.

Ilmenite.—It is a dark, heavy iron ore containing some titanium. It resembles magnetite in appearance, but is not magnetic. It is found as minute grains in many of the basic igneous rocks

in Mysore, but nowhere in sufficiently large quantities to be profitably mined.

Iron Ores.—Hæmatite, magnetite, ilmenite, limonite, etc., form some of the important ores of iron. Hæmatite and limonite occur in fairly large quantities in Mysore and they are being mined for manufacturing iron and steel.

Kaolin.—This is also known as china clay. A white, plastic, superior kind of clay formed from the decomposition of felspars in pegmatites, granites and gneisses.

There are numerous deposits in Mysore, and the material mined from them is being used for manufacturing fire bricks, stoneware pipes, porcelain articles, insulators etc.

Limonite.—A hydrous oxide of iron and forms one of its important ores. When occurring as yellow powder, it is known as yellow ochre.

Magnesite.—A dense, milk white mineral occurring as veins in the ultrabasic rocks in parts of the Mysore and Hassan Districts. In chemical composition, it is a magnesian carbonate. Used for manufacturing fire bricks, magnesia cement, Epsom salt and for several other purposes.

Magnetite.—A heavy, dark, magnetic ore. An oxide of iron, and it easily attracts a needle and other iron articles. Found as veins and masses in basic and ultrabasic rocks, and also, associated with quartz, constitutes an important rock formation in the southern part of Mysore.

Manganese Ores.—Among the numerous types of ores of manganese, only the oxide ores,—psilomelane and pyrolucite, and some earthy wad are found in Mysore. Comparatively, they are somewhat inferior in grade to the manganese ores found in the Central Provinces in India, and of late, in Mysore, this mineral industry has suffered a set back.

Monazite.—This is a phosphate of cerium metals. Contains some thorium oxide also which is largely

used for making gas light mantles. It occurs to a small extent, associated with beryl, in a pegmatite at Yediyur, near Bangalore.

Pyrite (Fool's Gold).—A yellow shining mineral occurring as cubes in chloritic and other schists in various parts of the State. On account of its yellow colour, it is very often mistaken for gold. It is a sulphide of iron. Auriferous varieties, however, may contain some gold.

Silver.—Silver ores have not been found in Mysore, but silver occurs combined with some of the lead ores (galena) near Chitaldrug, and also along with gold in the Kolar Gold Field.

Stibnite.—A very soft, dark grey, shining mineral which forms an important ore of antimony. In composition, it is a sulphide of antimony. This mineral occurs to a small extent, associated with antimony oxide, in the quartz veins near Chikkonnanhalli, Chitaldrug District.

Talc. (Steatite or Soapstone).—When pure it is a very soft, unctuous, apple green mineral. It may occur as thin veins or in larger masses when, generally mixed with other minerals, it would be impure. An impure variety of this—soapstone or potstone—occurs as large lenses and irregular masses associated with the Dharwar Schists, and as stringers, in the granitic areas. It lends itself to fine carving and many of the beautiful Hoysala temples in Mysore, like those at Halebid, Belur, Somanathpur and other places, have been carved out of this. The uses of purer varieties, are very many.

MYSORE GEOLOGICAL DEPARTMENT.

LIST OF PUBLICATIONS.

RECORDS OF THE MYSORE GEOLOGICAL DEPARTMENT.

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VOL. IV, 1902-03.

(*Out of Print.*)

Part 1.—General Report for 1902-03. Miscellaneous Notes. Ajjampur and Tarikere areas; Honnali and Channagiri Taluks.

Part 2.—Preliminary report on parts of the Tumkur, Bangalore and Kolar Districts with a map. The Anantapur Schist belt. Traverse notes from Dharmavaram to Hiriyur. Petrological description of rocks from Tarur hill, Sira Taluk. Geology of Ajjampur and Tarikere with a map. Note on Gedrite-bearing rock from Palwalli, Pavagada Taluk. The Lal-Bagh gneissic quarry, Bangalore. Preliminary report on country between Shikarpur, Davangere and Holalkere in the Shimoga and Chitaldrug Districts with map and sections. Notes on Magnesite, Mysore District. Asbestos near Bangalore. Occurrence of manganese ore near Madadkere, Hosdurga Taluk. Economic mineral products in the Kadur and Hassan Districts.

VOL. V, 1903-04.

Part 1.—General Report for 1903-04. Inspection notes of the State Geologist on the Kolar Schists, the Biligiri Rangan hills, the Bellara and the Bodimaradi gold mines, and on the Javanhalli and Chitaldrug Schist belts. Notes on the Sakrebail, Shankargudda and Kumsi areas. Traverse notes between Kallurkatte and Kodashadri, Shimoga District.

Part 2.—Report on the eastern portion of the Chitaldrug Schist belt lying between Aimangala and Nittur. The Javanhalli Schist belt with a map. A preliminary Geological report on parts of the Shimoga and Kadur Districts comprising the Kodashadri, Agumbe, Lakvalli and Shankargudda areas with a map. Asbestos occurrences. Mica at Hardur and at Chikkanhalli. Old workings for gold in the Hole-Narsipur and Channarayapatna Taluks. Pyrites, apatite and other mineral occurrences.

VOL. VI, 1904-05.

Part 1.—General Report for 1904-05.

Part 2.—Geology of parts of the Tarikere, Channagiri and Shimoga Taluks with a map. The Gangur and Ubrani iron ores. Mineral resources of the Mysore and Kadur Districts. Summary of Geological work in the Mysore and Tumkur Districts. The Malvalli iron ores (second notice). Traverse notes in the Nagamangala, Attikuppa and Hunsur Taluks. Geology of the Chitaldrug District with map and sections.

VOL. VII, 1905-06.

Part 1.—General Report for 1905-06.

Part 2.—Geology of the Shimoga, Tarikere and Kadur Taluks with map. The Kaldurga conglomerates. The Lakvalli and Nandi old workings for gold. Felsite and Porphyry dykes round Seringapatam with a map and appendix. Geology of the Hassan and Tumkur Districts with a map. The Bommanhalli and Nuggihalli Schists. Traverse notes in the Srinivaspur and Kadri Taluks. Report on the Geology of the Challakere and Sira Taluks with map.

Vol. VIII, 1906-07.

Part 1.—General Report for 1906-07. Short notes of a traverse from Banavar to Bhund Ghat. Review of the Geological work in the area south of the Kabbani river, and in the Sorab and Shikarpur Taluks. Iron ores near Sivasamudram.

Part 2.—Geology of the Sorab and Shikarpur areas with map. Petrological notes on the iron ore rocks in the neighbourhood of Maddur and Malvalli. Geology of the Gundlupet and Chamarajnagar Taluks with map.

Vol. IX, 1907-08.

Part 1. – General Report for 1907-08. Short notes on gold mining, iron ores and iron smelting, manganese and corundum. Bababudan Schists—a review.

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